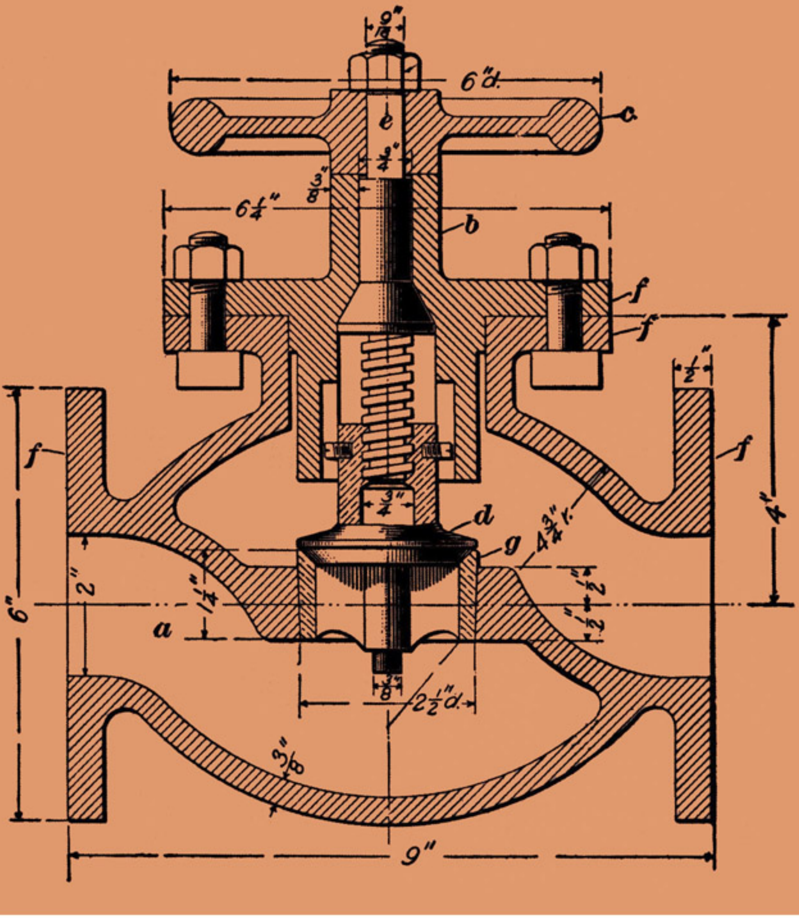
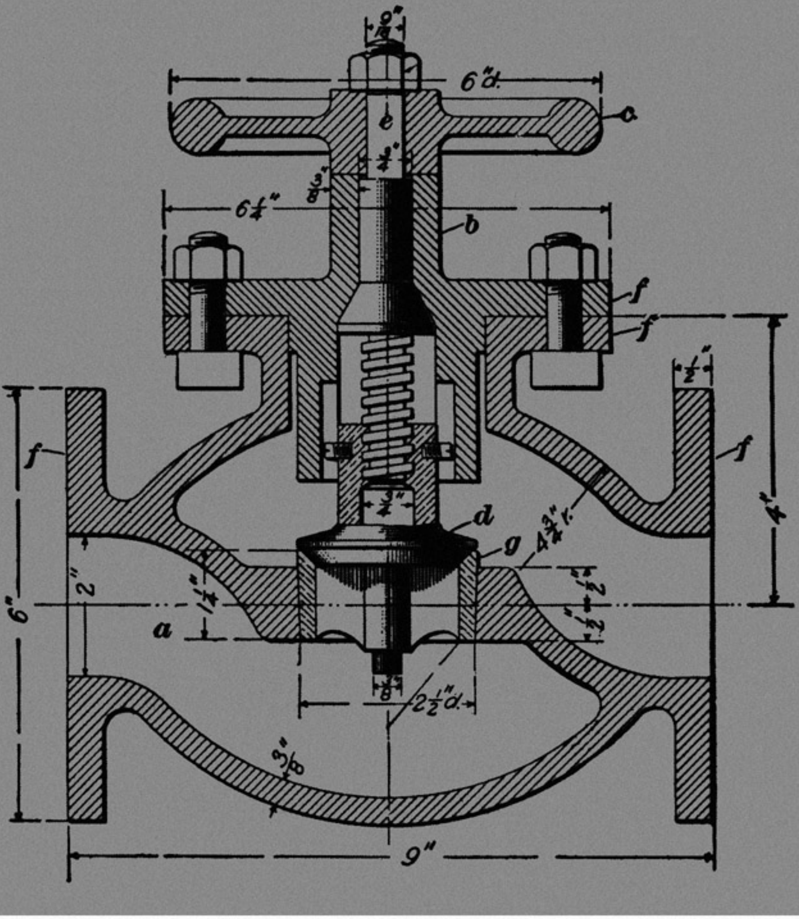


advanced pattern-making

"Lost Technology Series"



advanced pattern-making

"Lost Technology Series"

Advanced Patternmaking

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International Correspondence Schools

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INTRODUCTION

In other books, including those published by Lindsay Publications, the secrets of patternmaking have been revealed. Starting with basic woodworking tools and their use, these books have taught the beginner how to make basic patterns that could, in turn, produce strong economical castings.

After the home foundryman has read and mastered the information in these relatively rare patternmaking books, where can he go to get the advanced information he needs? Where can he learn the secrets of making those complex patterns that only the old-time expert patternmakers knew how to make?

Here it is! This reprint from a turn-of-the-century textbook starts where most other patternmaking books end. You'll learn the secrets of making complex valves, pipes, gears, flywheels, steam engine components, and many other common items. As rare as good patternmaking books are, advanced information like this is even more difficult to find.

Finally! You have the equipment to produce molten metal, and you have the flasks and sand to make molds. Here is the information that will allow you to produce the highest quality patterns. The castings you pour will be strong, use a minimum amount of low cost metal, and will need a minimum of machining. In other words, your creative use of patterns in your foundry will save you money and work, and that's smart!

Here is more rare information, that raw material that will allow you to accomplish all those things that only a short time ago looked so difficult. Here is knowledge. Use it. After all, knowledge IS power!

WARNING

Remember that the materials and methods described here are from another era. Workers were less safety conscious then, and some methods may be downright dangerous. Be careful! Use good solid judgement in your work. Lindsay Publications has not tested these methods and materials and does not endorse them. Our job is merely to pass along to you information from another era. Safety is your responsibility.

PATTERNMAKING.

(PART 3.)

EXAMPLES ILLUSTRATING PATTERNMAKING.

1. Selecting Stock for Patterns.—It may seem unnecessary, after what has been said in *Patternmaking*, Parts 1 and 2, to lay emphasis on the necessity of using great care in selecting stock for patterns. In the case of a skeleton or makeshift pattern, second-grade lumber is good enough, but in the case of a pattern for machine parts, especially when a large number of castings are required, and when the pattern may have to be stored for quite long intervals, the selection of the stock becomes a very important item. In such cases, only well-seasoned and well-selected lumber should be used. It is probable that more money is wasted by the use of poorly seasoned or unsuitable lumber in patternmaking than by any other one cause affecting this part of the machinery business. The evil consequences of the use of bad lumber not only increase the pattern account of a firm, but add considerably to the cost of molding and, also, to that of finishing the castings in the machine shop, since a pattern that is warped out of its original shape because it was made of wet lumber will give the molder trouble in molding; and the casting, being like the pattern, will cause the machinist trouble, thereby increasing the cost of production in all the departments because the patternmaker was not careful enough in selecting his material.

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SKELETON PATTERNS.

2. General Consideration.—When only one casting or a very few castings are required from a large pattern, means are sometimes taken in both the pattern shop and the foundry to make the required pattern as inexpensive as possible. At times, the pattern is swept up from sand and baked, and, again, it is often made of cheap second-grade lumber in the least expensive manner. In either of these cases, the pattern is practically of one material, that is, it is made either of sand or wood. In the class of patterns commonly known as **skeleton patterns,** the pattern is made partially of wood and partially of sand.

3. Pattern for Pipe Bend.—Two views representing half of a skeleton pattern for a large pipe elbow are shown in Fig. 1. To produce a whole pattern, two boards *a* are sawed out to the shape of the pipe, including the core prints.

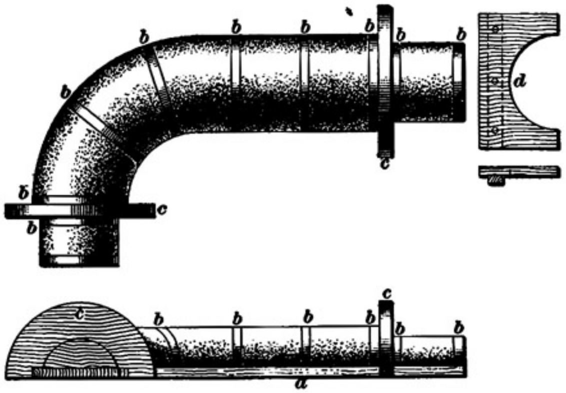


FIG. 1 (*a*).

The thickness of these boards depends on the size of the pattern and varies from 1 to 2 inches. The boards are doweled together and circular pieces *b*, *b*, having the form of the cross-section of the pipe and core prints at the places where they are introduced, are sawed out and fastened upon the boards, as shown. The flanges *c*, *c* are also prepared and cut out to fit over the boards *a*.

A strike, or strickle, for each diameter of the pattern, i. e., one for the portion between the flanges and one for the core prints, is also provided for the molder. One of these strickles is shown at *d*, Fig. 1 (*a*). The molder completes the pattern by laying down one of the boards, as shown in the lower part of Fig. 1 (*a*), and filling the spaces between the circular pieces *b*, *b* with sand, the sand being swept up by means of the strickle, which is guided by the board *a*. When the pattern is complete, the molder sprinkles parting sand over the outside so that it may leave the mold nicely. The flask for this first half of the mold is then placed in position, rammed up, and turned over, after which the other board *a* is placed on the one shown in the illustration, its half pattern finished up in sand, sprinkled with parting sand, and the second half of the mold rammed up. When the flask is taken apart, the cope usually draws off from the upper half of the pattern, after which the pattern is withdrawn from the mold and any loose sand that may have fallen from the pattern is removed.

The core for the skeleton pattern mold is simply swept up by means of a guide board and strickle. These are shown in Fig. 1 (*b*), *a* being the guide board and *x* the strickle. The guide board is clamped or weighted down on an iron plate and the half core swept up, as shown in the illustration, *d* being the core. The points *c*, *c* should be protected from excessive wear on the iron plate by driving one or more nails into them. After one half the core has been swept up, the guide board is turned over and the other half swept

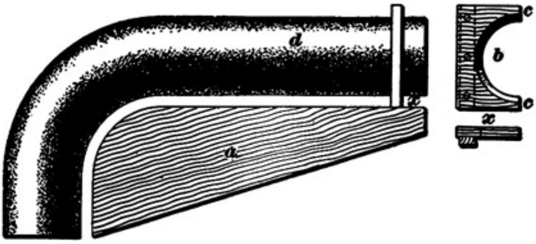


FIG. 1 (*b*).

up, to match the portion already made. During the work, one edge of the strickle is kept in contact with the guide board, care being taken to see that the strickle is always perpendicular to the guide board when following its straight portions, and perpendicular to a tangent, i. e., forming a radial line, when following the curved portions.

In some cases the plate on which the core is made is so shaped that the sides are parallel to the sides of the core, as shown in Fig. 1 (*c*), and the edges form the guides for the strickle. When this form of plate is used, the strickle is made as shown at *b*, the plate being shown at *a*.

In the case of large pipes, the skeleton patterns are frequently made so as to leave a core. The pattern is a frame having the same thickness as the metal and is so arranged that strickles can be used on the inside or outside.

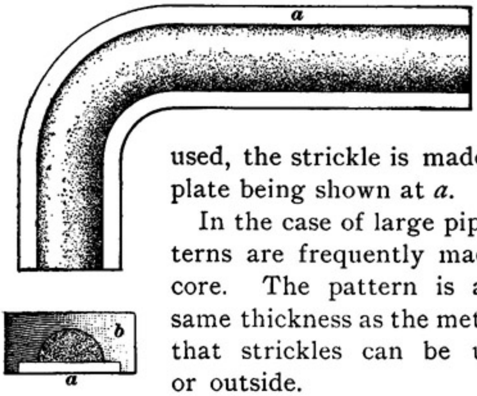


FIG. 1 (*c*).

4. Green-Sand and Loam Patterns for Large Pipe Bends.—Large pipe bends are usually made by building a skeleton pattern, as shown in Fig. 2 (*a*) and (*b*). This form of pattern may be used for green-sand or loam molding, the former method being used for sizes up to about 24 inches or 30 inches, and in most cases larger sizes are made by the latter method. The strickles, or sweeps, required for green sand and loam differ somewhat. Fig. 2 (*a*) and (*b*) show a skeleton pattern and sweeps for a green-sand mold.

The process of molding may be briefly described as follows: The half pattern is imbedded in the sand in the floor, and the sand between the ribs swept out with the sweep *a*, the offsets on the ends of which are equal to the thickness of the pipe, which is also represented by the thickness of the ribs of the pattern. This sweep leaves a comparatively smooth surface of the form of the outside of the pattern.

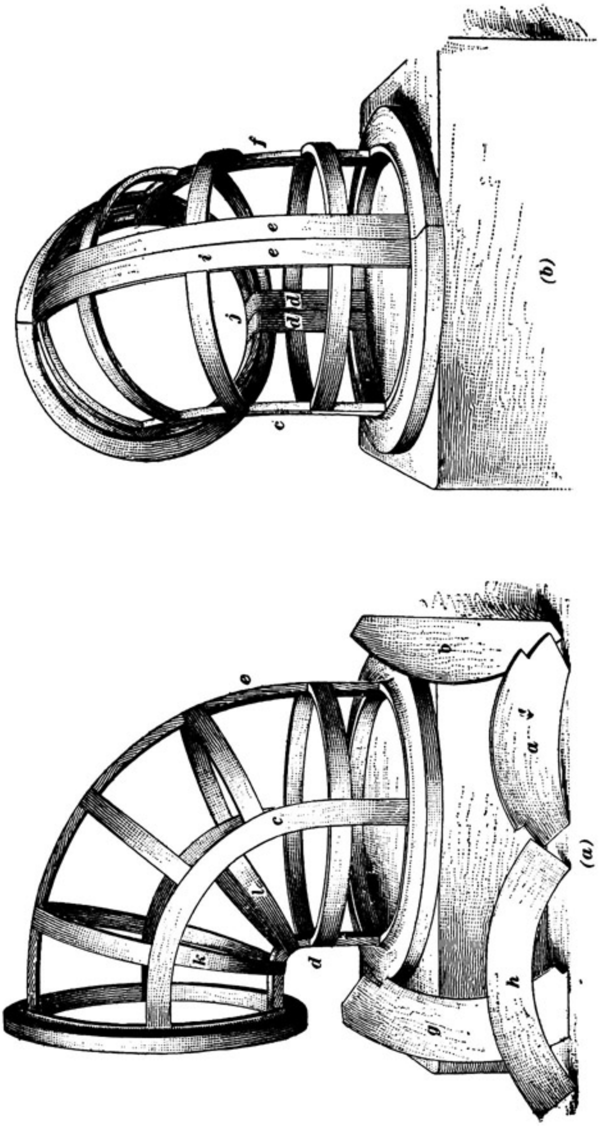
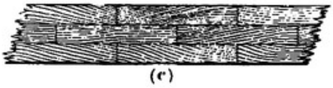


FIG. 2.

This surface is then covered with parting sand, the spaces between the ribs filled with molding sand, and the inner surface smoothed with the sweep *b*, which has the same curvature as the inside of the pipe. The sweeps are drawn along with the ends bearing on any two of the ribs *c*, *d*, *e*, and *f*. When this surface is smooth, it is covered with parting sand, and the core is made by placing an iron core crab in the center, and packing sand around it. When the core is built up roughly to the form of the pipe, the second half of the skeleton pattern is put in place, and the upper half of the core is swept up smoothly with the sweep *g*, and the surface coated with parting sand. The upper half of the pattern is then filled with sand, the surface swept up with the sweep *h*, covered with parting sand, and the remainder of the mold made up in the usual way.

It will be seen from the above outline that the pattern must be made in halves, and that four sweeps are necessary. One, of the form shown at *a*, is made with an outside radius equal to the radius of the outside of the pipe, and offsets at the two ends, as shown, equal to the thickness of the pipe. The sweeps *b* and *g* are made, the first with an outside, and the second an inside, radius equal to the radius of the inside of the pipe, the latter also having offsets at the ends equal to the thickness of the pipe. The fourth sweep *h* is made with an inside radius equal to the radius of the outside of the pipe.

The skeleton pattern is made by turning up the flanges and cutting out the ribs separately, then putting them together as shown. The pattern is parted along the lines *i* and *j*, Fig. 2 (*b*). The ribs *d* and *e* are usually built up in three widths that overlap each other, as shown in Fig. 2 (*c*), although in the smaller sizes, *d* may be cut out of solid stock. The other ribs are generally made from solid stock, and with *d* and *e* are sawed to the required form. The joints are usually made with nails. The flanges are built up of three thicknesses of stock, and the fillets are



(*c*)

FIG. 2.

turned on them. It will be seen that the ribs *k* and *l*, forming the inside of the bend, are made with a taper. This is done in order to leave as wide a space as possible at the lower end, which makes it easier to ram in the sand.

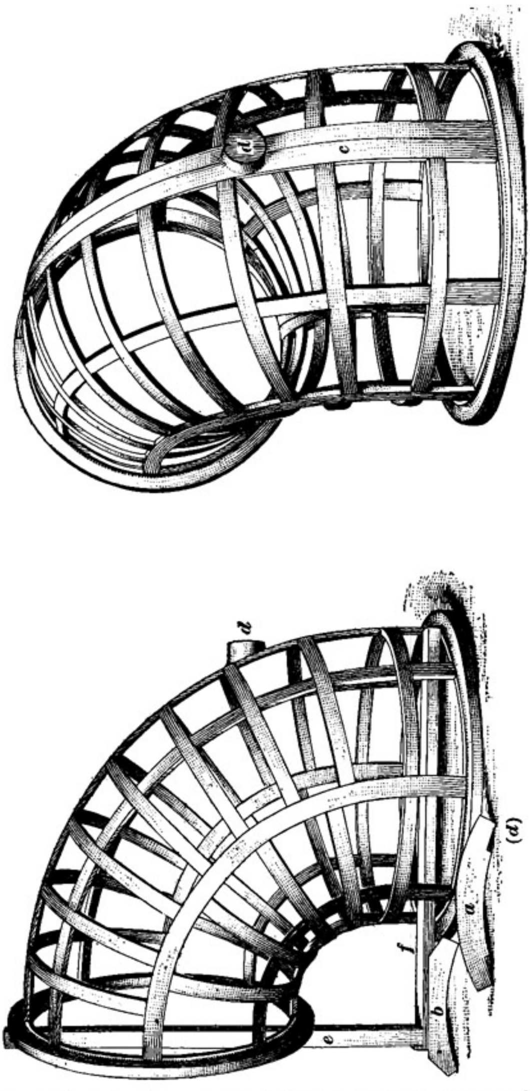


FIG. 2.

In Fig. 2 (*d*) and (*e*) are shown two views of a skeleton pattern of a larger size, intended for loam work. In this case, the elbow is molded on end, the core being built up first in one piece; the sand is then filled in to form the pattern, and the mold built up on the outside in two or more pieces. It will be seen that in this case only two sweeps are necessary. The first *a* is used to sweep up the core, and is made with an inside radius equal to the radius of the inside of the pipe and offsets at the ends equal to the thickness of the pipe. The second *b* is made with an inside radius equal to the radius of the outside of the pipe. The pattern is parted along the line *c*, and is made in the same way as the green-sand pattern. The hub *d* is provided for a carrying bolt, to facilitate the handling of the finished casting. The supports *e* and *f* are provided for the purpose of preventing the end of the pattern from settling while in storage.

PATTERNS INVOLVING AUXILIARY PATTERNS.

TOOL FOR LAYING OUT HEXAGONAL PARTS.

5. In a number of the following examples, it becomes necessary to lay out a hexagonal part of the pattern, and a very convenient tool for this purpose, and one that can easily be made by any patternmaker, is illustrated in Fig. 3. This tool is made by fastening a metal plate or plates on a wooden frame, as shown, *b* being a cross-section at that point. In the metal plate, an angle *f a g* of 60° must be cut. The wood mounting for the metal plate must be cut to another angle *h a i*. In order to find this second angle, draw the line *a e* bisecting the angle *f a g*, and at any point, as *o*, draw

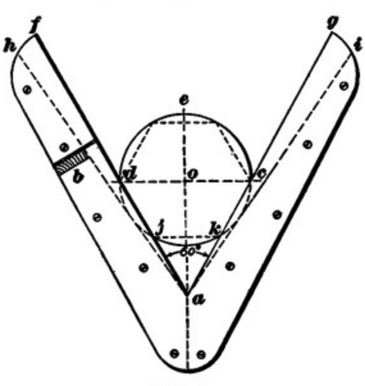


FIG. 3.

the line *d c* perpendicular to *a e* at *o* and intersecting the lines *a f* and *a g* at *d* and *c*. With a radius *o d*, or *o c*, draw the circle *d e c*. Then draw the lines *a i* and *a h* tangent to the circle *d e c*, and cut the wood to this angle. When this tool is placed upon any circle, as shown, it will determine two sides of a hexagon, the distances *d j*, *j k*, and *k c* all being equal. The stock has then simply to be turned to the diameter over the corners of the hexagon, commonly called the long diameter of the hexagon, after which the hexagon can be laid out by using the tool, as shown in the illustration.

GLOBE-VALVE PATTERNS.

6. General Consideration.—Small **globe valves** are generally cast of brass, while the larger sizes are made of cast iron. The latter are also known as *stop-valves*, and sometimes as *throttle valves*. The method of making the smaller sizes differs from that of making the larger, the former being molded by machine from several patterns attached to the plate, with a gate connecting all the patterns. As many as eighteen patterns of very small-sized globe valves are often attached to one gate on the plate and molded together. When this is done, the portion of the pattern on one side of the parting line is mounted on one side of the board, and the portion on the other side of the parting line on the other side of the board, great care being required to place the portions exactly opposite each other. The methods of molding with this style of patterns will be treated in *Foundry Work*.

7. Pattern for Small Valve Body.—The method of making the pattern and core boxes for a 1¼-inch globe valve will next be considered, only one pattern being treated, although two or more may be molded in one flask. The manner of making the pattern and core boxes is the same, whether one or more patterns are required, or whether they are required for matched-board work or not. Fig. 4 (*a*) and (*b*) represents two views of a globe valve, (*a*) being a section.

8. The making of the pattern for the body will be considered first. This pattern is comparatively simple, it being

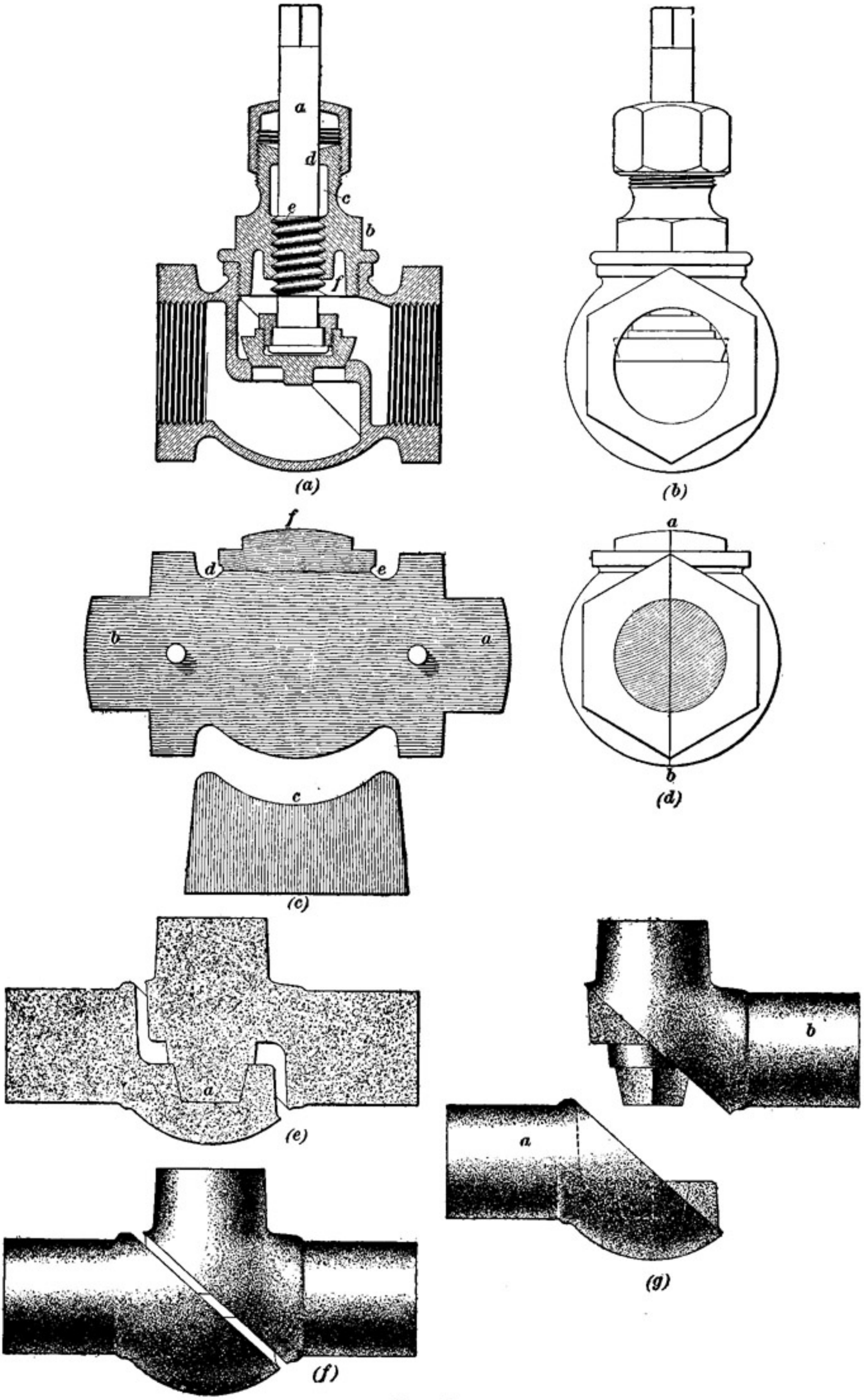


FIG. 4.

possible to turn most of it on a lathe. Fig. 4 (*c*) and (*d*) illustrates the pattern, together with several of the points in its construction. Two pieces of stock about 8 inches long, 3 inches wide, and 1½ inches thick are cut out and jointed and doweled together carefully. The stock is made of this length in order to enable the patternmaker to glue the ends together so as to hold the pieces in place during turning. When this method is followed, care should be taken that no glue gets between the parts of the pieces that are to form the pattern. Sometimes a nail or screw is also placed in the end to aid the glue in holding the pieces together. If, however, good glue is employed, and it is allowed to dry before turning, these metal fasteners are not required in the case of small patterns.

A templet should be made as shown at *c*, Fig. 4 (*c*). This templet may be made from a board ⅛ inch thick, or from a piece of sheet metal, and is used as a guide in turning the pattern to the right shape, the proper allowance being made for finish and shrinkage. The ends on which the hexagons are made are usually turned a little larger in diameter than the long diameter of the hexagon, as, otherwise, in forming the hexagon there is some danger of making it too small.

After this first portion of the pattern has been turned, the globe body must be planed off to the line *d e*, as shown, and a piece turned and glued on to form that part of the valve into which the bonnet *b*, Fig. 4 (*a*), is screwed. The two core prints *a* and *b*, Fig. 4 (*c*), are turned on the body of the pattern, and the core print for the bonnet, *f*, Fig. 4 (*c*), is turned on a piece that is glued upon the side as shown. This piece should be turned from two pieces that have been jointed and fastened together on a chuck. Care should also be taken to see that the grain runs in the same direction both in the body of the pattern and in the piece that is glued to it.

9. Varnishing the Patterns.—After turning any pattern with core prints, and before taking it out of the lathe, it is well to varnish the core prints with yellow shellac varnish. If this is done, the unclean appearance that they usually have as the result of handling before the varnish is applied is avoided. This precaution applies only in cases where the core prints are simply painted with yellow varnish and not with a color.

After the turning is completed, the hexagonal ends of the pattern are formed, as shown in Fig. 4 (*d*).

10. Core Boxes for the Body of Globe Valves.—The core boxes and the core that forms the inside of the valve are not as easily made as the pattern. The exact shape of the core should be studied carefully before attempting to make the core boxes. In Fig. 4 (*e*) is shown a section through the core; Fig. 4 (*f*) shows the completed core together; and Fig. 4 (*g*) shows the two parts *a* and *b* separated. It is practically impossible to make such complicated cores as these in ordinary wooden boxes, and hence it is necessary to make iron core boxes, and patterns for these must also be made. These patterns are called **auxiliary patterns.** The finished core box for making the core shown at *a*, Fig. 4 (*g*), is shown in

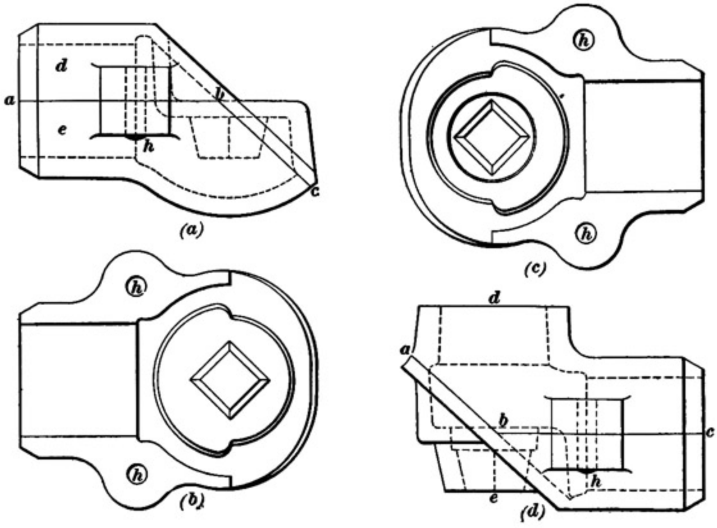


FIG. 5.

Fig. 5 (*a*) and (*b*), while in Fig. 5 (*c*) and (*d*) is shown the core box for making the core shown at *b*, Fig. 4 (*g*). These core boxes are usually made of cast iron or brass, nicely fitted and doweled together.

Four patterns for the boxes are made first, one for each half, and, as will be seen by referring to the inside views of both boxes, much cutting and fitting is necessary for their completion. Both boxes are parted along the lines *a b c*, and the joint between the two parts of the boxes must be made with great care, as the accuracy of the core depends very largely on it. The patterns for the core boxes should be made of well-seasoned blocks of pine or hard wood. No attempt should be made to carve the inside of the boxes to shape until the joint has been accurately formed, only enough work being done on the inside to enable the stock to be brought into place along the joint.

11. In making core boxes for the body of globe valves, it is sometimes best to make models of the required cores out of plaster of Paris or wood and then cut these models on different lines so as to obtain sections, or to make templets by simply projecting sections of the boxes upon a drawing. After the insides of the boxes have been carefully worked out to templets made from drawings, or to a model that has been prepared, castings are made from the patterns and fitted together with dowel-pins.

A projection of the upper part *d*, Fig. 5 (*a*), of the box for the core shown at *a*, Fig. 4 (*g*), is shown in Fig. 5 (*b*). It will be noticed that in Fig. 5 the halves of the patterns are joined together by dowel-pins *h*. After the castings for the core box have been made and fitted together, test cores are made from plaster of Paris or lead, put together, and located in the mold to see that the core gives the required thickness of metal. If it does not, the box is changed until it is right, or the pattern is changed and a new box cast. Frequently, cores are made in a new core box, placed in a mold and a casting made, from which sections are cut to see that the metal is of the desired thickness.

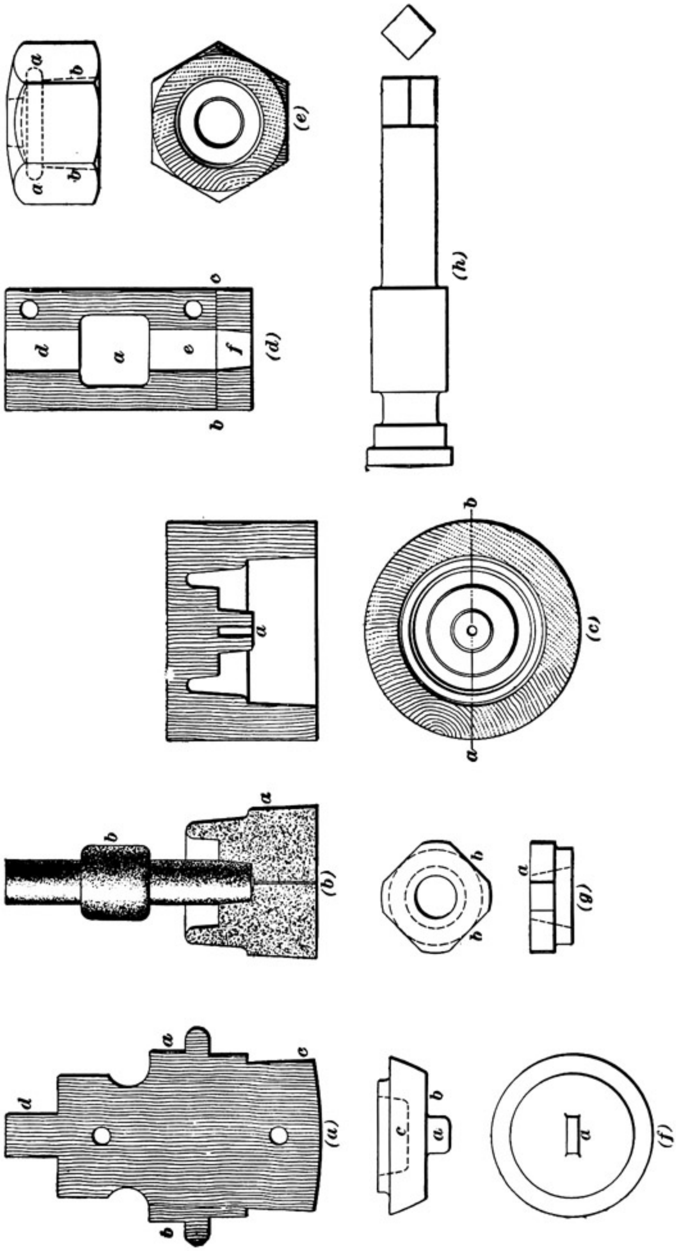


FIG. 6.

12. Manufacturers of valves spare no expense in making these metal core boxes and are very careful to get them correct, because of the large number of valves made. The core box for the core *b*, Fig. 4 (*g*), is shown at Fig. 5 (*d*), Fig. 5 (*c*) being a projection of the lower portion. It will be noticed that the core box shown in the two views (*a*) and (*b*), Fig. 5, has only one opening through which the core material can be introduced, this opening being at the end *a*, while the core box shown in Fig. 5 (*c*) and (*d*) has three openings, one at the end *c*, one at *d*, and another at *e*.

13. Pattern for the Valve Bonnet.—The pattern for the valve bonnet *b*, Fig. 4 (*a*), may be made as shown in Fig. 6 (*a*), which illustrates one-half of the pattern. In order to make the pattern, two pieces of pine should be jointed and doweled together in the ordinary way and the pattern turned to the form shown, necessary allowance being made for finish. After the pattern is turned, the core print should be varnished and the hexagonal portion *a b* given the required form, using the tool described in Art. **5.** The large core print *c* is turned a little larger on the end than where it joins the pattern, for reasons that will be described later. The small core print *d* is turned parallel.

14. Core Boxes for Valve Bonnet.—By referring to Fig. 4 (*a*), it will be noticed that the bonnet *b* has a rather complicated core, the portion *c* being cored out for clearance, while finish will be required at *d* to form the bearing for the valve stem *a*, and at *e* for the thread, the lower portion *f* being cored out both for clearance and lightness. In order to produce this complicated series of openings, two cores are necessary. These are illustrated in Fig. 6 (*b*), the larger core *a* being represented in section, and the smaller core *b*, solid. When similar cores are made larger, the smaller one should be arranged to go through the larger one, so as to give it better support, but for small work, such as is here illustrated, the method shown will give sufficient strength.

15. The core box for the larger core is shown in Fig. 6 (*c*). This may be turned up on a screw chuck from a single piece of wood, the grain running in the direction shown in the illustration. The reason for making the large print *c*, Fig. 6 (*a*), on the pattern tapered is that this box must be given draft on the inside, to allow the removal of the core. The small print *a*, Fig. 6 (*c*), is to receive the end of the small core, as shown in Fig. 6 (*b*). When making a core from these boxes, a nail or wire should be inserted into the hole in the end of the print *a*. When the core is rammed up, this nail is withdrawn, leaving a hole through the core, as shown in Fig. 6 (*b*).

Owing to the small size of the core *b*, Fig. 6 (*b*), it is well to make both halves of the box, for, if such small half cores were pasted together, they would not be as strong as the solid core. Fig. 6 (*d*) illustrates one-half of the necessary core box. The chamber *a* may be cut out with a carving gouge, or a box may be made in several pieces and each worked or turned out by itself. It is customary to make the box of at least two pieces, dividing it on the line *b c* so that the straight portions *d* and *e* can be worked out parallel and the tapered portion *f* turned out by itself.

16. Patterns for Small Details of the Valves.— The pattern for the packing nut can be made as shown in Fig. 6 (*e*), which gives both a plan and an elevation of the nut. This pattern can be made to leave its own core by turning it out on the inside, as indicated by the straight dotted lines *b* in the upper view, the recess *a a* being omitted. In such a pattern as this, the grain is usually allowed to run lengthwise of the nut, the end grain being shown in the lower view. To make this pattern, a piece of wood is placed on a screw chuck and the outside turned to a diameter sufficient to allow the hexagon to be formed. Sometimes, a more elaborate solid pattern is made for the nut and a separate core box used. This is always done when it is desired to core out a clearance at the upper end of the nut, as shown by the dotted lines at *a*, Fig. 6 (*e*).

17. The patterns for the valve and valve nut may be turned from one piece of wood, the wood being screwed on to a small face plate or screw chuck, and the valve pattern, Fig. 6 (*f*), is turned as shown in the illustration, with the exception of the portion marked *a*. In turning, the face *b* should be toward the chuck, so as to enable the patternmaker to turn out the recess *c*. After the pattern is turned nearly off, it should be smoothed and varnished and then cut off. The rectangular projection *a* is fastened on afterwards, it being intended for the use of the machinist while grinding in the valve. After the valve has been cut off, the nut, Fig. 6 (*g*), can be turned, the face *a* being nearest the chuck during the turning. After the piece has been turned, smoothed, varnished, and cut off, the flats *b* for the wrench may be formed with a plane or chisel. The valve spindle, Fig. 6 (*h*), can be turned from one piece as shown. Patterns of small diameter like the valve spindle are not usually made in halves, because they would be too weak, and liable to break.

18. Where a large number of castings is to be made, it is very common practice to make such pieces as the valve nut and valve spindle in halves and to place them upon a card or a match board. At other times, the patterns are all made solid and a match, or odd side, is made from plaster or oiled sand, separate places being made to receive each pattern.

PATTERNS AND CORE BOXES FOR THREE-WAY COCK.

19. General Consideration of the Valve.—Before attempting to make the patterns for this valve, it is well to look somewhat into its characteristics. In Fig. 7 (*a*) is shown a plan of the top of the valve, and in Fig. 7 (*c*) is shown a front view, while Fig. 7 (*b*) shows a section of the valve on the line *A B*. It will be noticed that there are stops *s*, *s'* on the casting, against which the pin *a* on the plug or

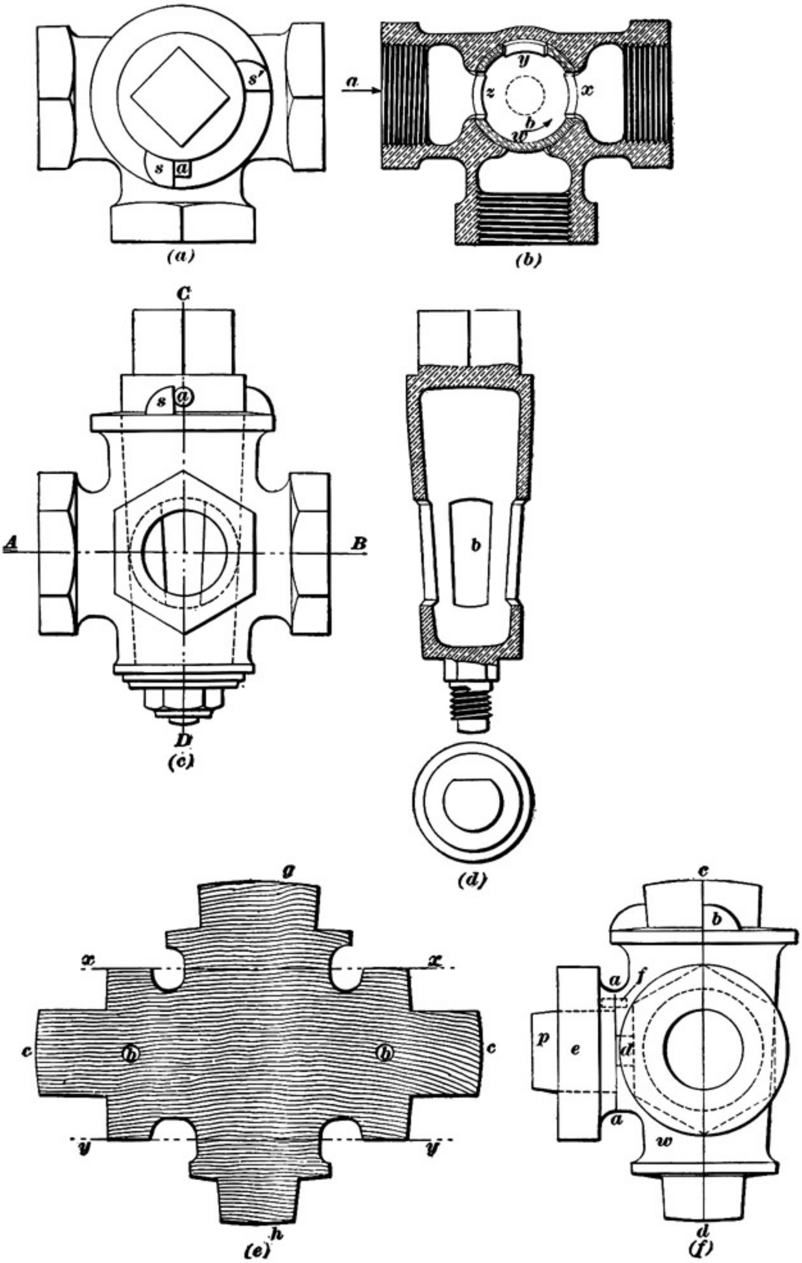


FIG. 7.

valve comes to rest. These stops are so placed that the plug cannot make more than a quarter of a revolution. The construction and operation of the valve can be best understood by referring to the sectional view shown in Fig. 7 (*b*). As shown in this illustration, the plug is in such a position that the openings *x* and *z* are in line with the straight portion of the body, so that water or steam entering at *a* passes straight through the cock. By turning the plug one-fourth of a revolution, as indicated by the arrow *b*, the opening *x* will come to the position *y*, the opening *y* will come to the position *z*, and the opening *z* to the position *w*, thus turning the flow at right angles and out through the side of the cock at *w*.

20. In making patterns and core boxes for this cock, the necessary allowance for shake, shrinkage, and finish must be made in each case. The outside of the main body of the pattern and much of the inside will require no finish, and, also, in many cases, the hexagonal parts are cast to their finished size; but the portions that have to be threaded and the portion of the body that is to receive the plug must be provided with sufficient stock for finishing.

21. Pattern for Valve.—The pattern for the valve is made in two parts, with a third part fitted to one side, as shown in Fig. 7 (*f*). One half of the pattern is shown in Fig. 7 (*e*). The pattern is parted on the line *c d*, and the hexagonal side piece *e*, with its fillet, is made separate from the body of the pattern, the division being made along the line *a a*. This piece *e* has a hole turned through it that fits over the core print *p*.

To make this valve pattern, two pieces of stock of sufficient size to make the piece shown in Fig. 7 (*e*) must be gotten out. These pieces are jointed and doweled together, the dowels being located at *b* and *b*, as shown in Fig. 7 (*e*). The pieces of stock may be gotten out somewhat longer in each direction than the pattern, and secured together by glue at the ends, or they may be glued together with paper between them.

If it is intended to make the body of the pattern without fastening on separate pieces, all the work cannot be done by turning, but a portion of it will have to be done with gouges and chisels after the turning is completed. Before turning, two lines should be laid off on the block at right angles to each other. These will correspond to the center lines *A B* and *C D*, Fig. 7 (*c*). A portion of the pattern along the line *A B* may be turned first. While in this position, only the core prints and the pieces from which the hexagonal ends are formed, together with their fillets, can be turned. When this operation is completed, the pattern is placed in the lathe at right angles to its former position and the other two core prints, and the part of the pattern outside of the dotted lines *x x* and *y y* is turned. It should be noticed that the core prints *g* and *h* are turned tapered and that the taper of the two prints is in line; that is, their outside surfaces will form a portion of the surface of a cone. The reasons for this will be explained later.

22. After the pattern is turned, the portion of the body that could not be finished in the lathe is formed by means of chisels and gouges, but, before proceeding with this work, it is best to true up the surface *a a*, planing it off parallel to the joint of the pattern along the line *c d* and allowing the proper distance between these two faces. After the surface *a a* has been planed, a circle is struck on it with a diameter equal to the distance *a a*. The body of the valve is then carved to the desired shape. The print *p* is shown by the dotted lines as extending to the surface *a a*. This print is turned with the small pin *d* on the end, which is glued into a hole drilled in the surface *a a*. The loose piece to form the hexagonal flange *e* can be turned up with a hole in it that will just fit over the core print. This piece is kept in its proper relation to the body of the pattern by means of the small dowel-pin *f*.

It will be noticed in Fig. 7 (*a*) and (*c*) that the stops *s* and *s′* are slightly removed from the center lines. If it is attempted to mold the stop *s′* in its proper position, the molder will meet with considerable difficulty, but as the distance of the stop from the center line *C D* is only equal to half the diameter of the pin *a*, Fig. 7 (*c*), it is possible to place the stop on the pattern flush with the joint, as shown at *b*, Fig. 7 (*f*), the stop being filed back the desired distance after the casting is completed.

23. Method of Molding.—Before proceeding with the discussion of the core box, it may be well to notice the method of molding this pattern, as this has considerable bearing both on the construction of the pattern and on the core box. The portion of the pattern marked *w*, Fig. 7 (*f*), is supposed to go in the **cope,** or top part, of the mold and is shown there in Fig. 8 (*a*). In this illustration, the bottom part of the mold, or **drag,** has been omitted. The slab core *c* is shown as fitting over the core print *p'*. In the process of molding, before the slab core is placed in position, the pattern with the loose piece about the core print is placed in position and sand rammed up in the cope as far as the surface *p p*, flush with the top of the loose piece of the pattern. This sand is then struck off and the loose piece withdrawn, after which the slab core is placed over the core print, the surface resting on the surface of the sand *p p*. The ramming of the cope is then continued, care being taken not to strike the slab core while this is being done. This method may be pursued where only a comparatively small number of castings is to be made. When a large number of castings is being made, it is usual to provide the mold with an extra parting line; in other words, to mold the casting in a three-part flask. The slab core is made in a simple rectangular core box with one print in the bottom.

24. Core Box for Three-Way Cock.—One of the core boxes for the body of the three-way cock is shown in Fig. 8 (*b*). It will be noticed that the main portion of the core is tapered, and from this it will readily be seen why the core prints *g* and *h* in Fig. 7 (*e*) were tapered. By making these core prints tapered, and having this portion of

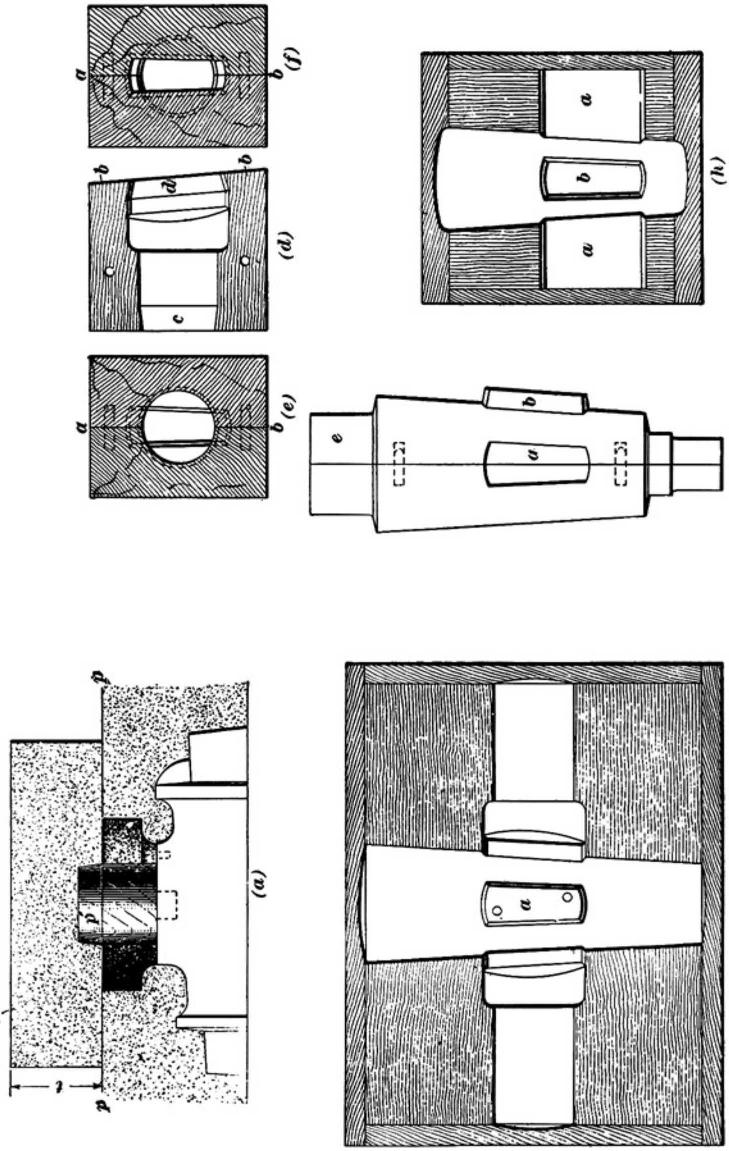


FIG. 8.

the core box formed as shown, it is much easier to work out the material to the desired form.

A one-half box is sufficient for this core, as both half cores are similar, the only difference being that one half core must be made without the print *a* shown in the box. The print *a* is, therefore, doweled on so that it may be removed and readily set in place again. This print is intended to receive the end of the side core that is made in the box shown in Fig. 8 (*d*).

The stock for this core box, Fig. 8 (*b*), must be thick enough to leave sufficient strength in the back after cutting away the material at the largest diameter. Four pieces are secured to the outside of the box, as shown, and clearance for draft on the ends of the core is cut from these pieces.

25. The core for the side opening is made separate. Fig. 8 (*d*), (*e*), and (*f*) shows three views of the box intended for this purpose. A complete box should be made for this core, the parting being on the line *a b*, and the two pieces doweled together, as shown. The end *b b*, Fig. 8 (*d*), must have the same taper as the plug part of the main box. The portion *d*, which is intended to form the projection that goes into the print left by the piece *a*, Fig. 8 (*b*), must be shaped to correspond with the print it is intended to fit, and the end *c* must be formed to correspond with the print *p* on the pattern Fig. 7 (*f*). The general construction of the box needs no comment, as it is similar to the core boxes already described.

26. Pattern for Plug.—The pattern for the plug is shown in Fig. 8 (*g*) and is made in halves, being parted diagonally across the square head, as shown. This pattern has three core prints, the two prints *a* on the parting line, and the print *b* on the side. The two prints *a* may be formed by letting in a piece of wood that will go directly across the pattern, the grain being at right angles to the main portion of the pattern. This is the strongest construction. The print *b* can be made of a separate piece of wood and be attached to the main portion of the pattern. On the square end *e* of the pattern no allowance for finish will be required, but on the rest of the surface an allowance must be made.

27. Core Box for the Plug.—The manner of coring out the plug is shown in Fig. 7 (*d*). If a half box is made to serve for making both halves of the core, it will be necessary to fit a loose piece into the recess *b*, so that one half of the core can be made without the projection that forms the side opening *b*, Fig. 7 (*d*). One point that must be observed in making the core and locating the core prints for the plug, is that the core is supported by the prints *a*, *a*, Fig. 8 (*h*), and hence this portion of the core box and pattern must be made very carefully, so that the prints will make a good fit in the mold, for, if they do not, the plug is liable to be thin on one side and thick on the other.

PATTERNS FOR WHEELS AND GEARS.

28. Wheels or Gears Having a Web or Plate in Place of Arms. — When the diameter of wheels is not great, as, for instance, in the case of small gears or pinions, a plate or web takes the place of a series of arms. In case the pattern is divided into two parts, the web, if thin, may be placed entirely on one part, the other half of the rim and the hub being made loose, or each half of the pattern may be made with one-half of the web. In either case, the stock for the web can be joined up as shown in Fig. 9. When the web is composed of six parts, as shown in Fig. 9, these parts may be sawed out from the board or plank, as shown at *a*. The

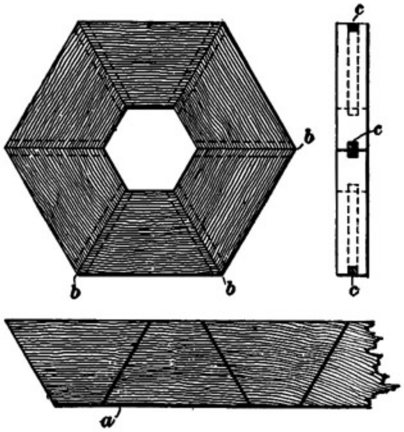


FIG. 9.

ends of the pieces should be finished on a trimmer and shoot board, so as to make perfect joints at *b*, *b*.

29. In order to strengthen these joints, a tongue *c* should be introduced into each joint. These tongues should be made of hard wood with the grain running at 45° to the joints. Any number of pieces can be gotten out in a manner similar to that shown at *a*. After the pieces are glued together, as shown, they may be sawed to approximately the required diameter with a band saw, and the courses, or segments for the rim, built up on the disk. It is usually unnecessary to have the pieces extend to the center, as the hub will cover this central opening, although there are times when it becomes necessary to make a solid web without the hole in the center. In such a case, it is easier to leave a small opening at the center and stop it by gluing in a separate piece.

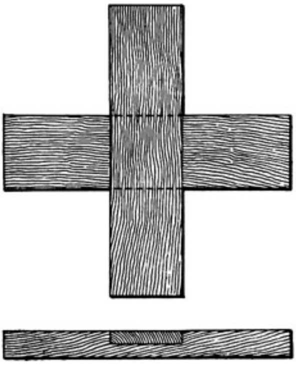


FIG. 10.

30. Wheel Patterns Having Four Arms.—When four arms are required, they are usually half checked together when the thickness at the center will permit doing so. Figs. 10 and 11 illustrate two methods of checking together two forms of arms. In Fig. 10 the arms are broad and flat and the pieces are simply checked together. In Fig. 11, the required arms are of considerable depth, and hence must have considerable draft. It will therefore be necessary to make the joint between them at *a* equal to the width *b* of the narrowest side of the arm.

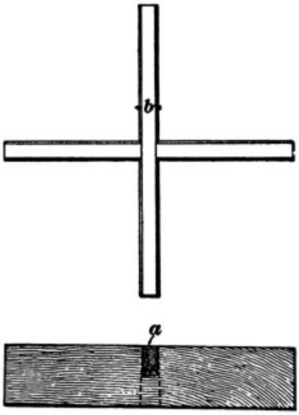


FIG. 11.

31. Wheel Patterns With Six or More Arms.—When six or more arms are required, they may be joined together as shown in Fig. 12. When this method is employed, the pieces are prepared as shown in Fig. 12 (*a*), each piece being wide enough to form the round corners of the arm near the hub and rim, and long enough to allow the ends of the arms to be built into the rim of the wheel. The pieces are joined together with tongues, as shown, the joints at the center being made by means of a trimmer and shoot board. The outline of the finished arms is shown in the dotted lines, Fig. 12 (*b*), and the hub is shown in Fig. 12 (*b*) and (*c*).

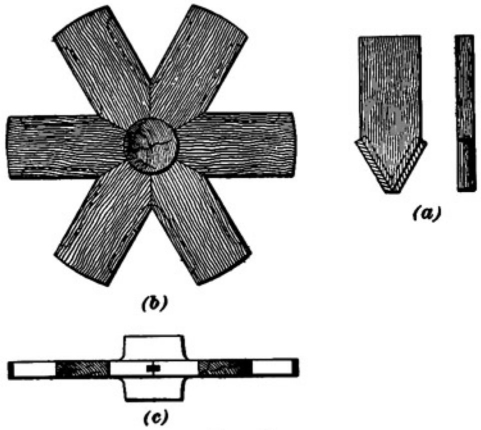


FIG. 12.

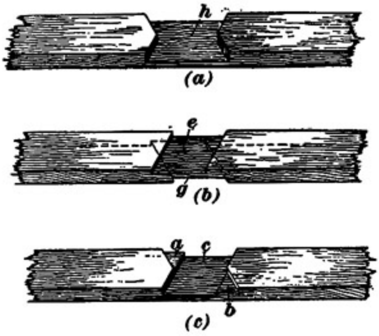


FIG. 13.

32. When the stock of the arms is thick enough to allow it, the method of joining shown in Fig. 13 may be employed. In this case, the joint is made as follows: The stock for the arms is dressed to the required width and thickness and a line made lengthwise on the center of both faces of each piece with a gauge. At the middle of the line on one side of the pieces shown in Fig. 13 (*a*) and (*c*), and at the middle of the line on both sides of the piece shown in Fig. 13 (*b*), a circle equal to the width of the piece is struck with a pair of dividers. In the case of six arms, a bevel is set to 60° and one set of lines laid off tangent to the circle and, in the case of (*a*) and (*c*), the bevel is then reversed and two other lines are laid off on the same side, which will cross the first ones at the center. The piece shown in Fig. 13 (*b*) is marked in the same way, except that instead of the four lines being on one side, two are on one side and two on the other, as shown. The gauge is now set to one-third the thickness of the stock and marks made along the edges of the arms. The pieces shown in Fig. 13 (*b*) and (*c*) are gauged from both sides, while the one shown in Fig. 13 (*a*) is gauged from one side only.

The first operation of checking is carried out as follows: The piece shown in Fig. 13 (*a*) is checked on both lines to two-thirds its depth in the first operation. The piece shown in Fig. 13 (*b*) is checked on alternate sides to one-third its depth, as shown, while in the case of the piece shown in Fig. 13 (*c*), the checking is carried out in two operations. In the first operation, the checking extends to one-third the depth, so as to obtain the surfaces *a* and *b*, which shall be equal in depth to the check shown at *e*, Fig. 13 (*b*). After this portion of the material has been removed, the stock is checked along the other two lines to the gauge lines representing two-thirds the thickness of the stock, so as to obtain the surface *c*.

If these three pieces have been accurately cut as described, they will fit together so as to form six arms. Before gluing the pieces together, care should be taken to see that the joints do not fit too tightly, as this may distort the arms, tending to bend them out of the plane in which they belong.

PATTERN FOR SHAFT COUPLING.

33. General Consideration of Casting Required. The finished casting is shown in Fig. 14 (*a*) and (*b*). This casting is to be finished all over, with the exception of the recess *a*, and hence stock must be allowed on all surfaces to be finished both inside and outside. No allowance is made for the bolt holes *b*, as these will be drilled subsequently through the solid metal.

34. Construction of the Pattern. — Fig. 14 (*c*) shows a section of the pattern, and Fig. 14 (*d*) a view of the lower side. It will be noticed that the disk is built up of two layers, or courses, *a* and *b*, the courses being joined together like those shown in Fig. 9, except that the tongues are omitted. These tongues are unnecessary in this case, because the two courses are arranged so as to break joints, as indicated by the dotted lines in Fig. 14 (*d*). The hub *c* and the core print *d* are turned separately, with pins on them to fit the hole *g* in the disk, thus making it easy to have them concentric with the outer circle of the coupling. The core print *d* should remain loose so that it may be removed for laying the pattern flat on the board in the first operation of molding.

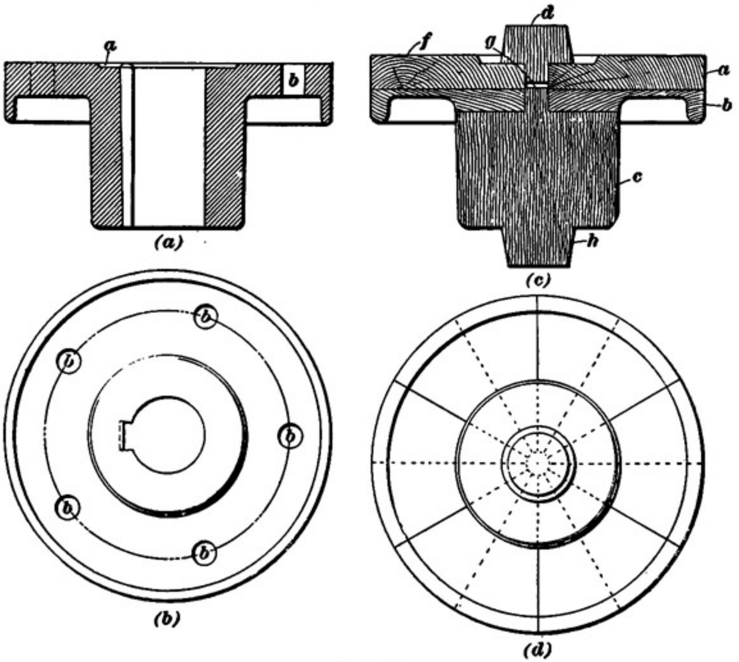


FIG. 14.

The hub is glued in place. In this pattern, draft is allowed on all surfaces from the face *f*. The core print *h* is turned with the hub *c*.

PATTERNS FOR CYLINDER HEAD AND COVER.

35. Construction of Cylinder Head.—The cylinder-head cover chosen to illustrate this style of pattern is shown at Fig. 15 (*a*) and (*b*), the cylinder head being intended for

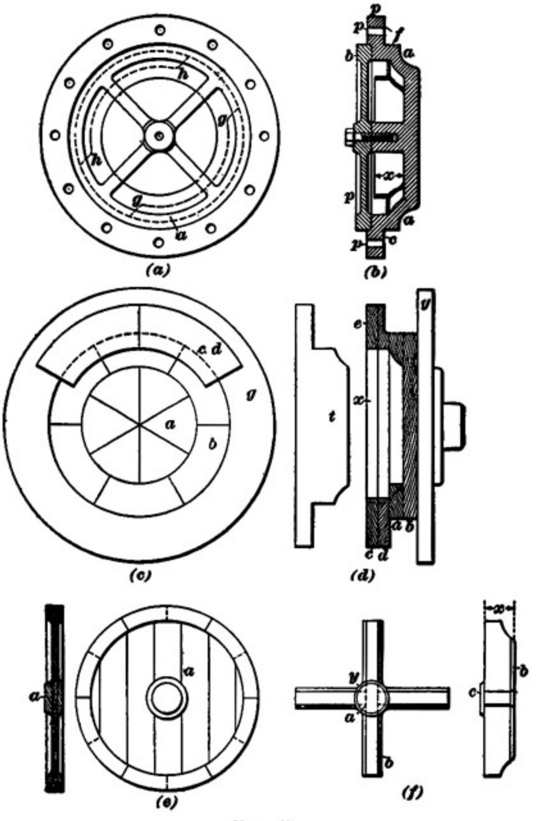


FIG. 15.

a Corliss engine. Fig. 15 (*b*) shows a section of the head with the cover *b* in place. This same head may also be used for a slide-valve engine by filling up on the pattern one of the spaces marked *a*. These spaces are also shown by dotted lines in Fig. 15 (*a*).

36. Pattern for Cylinder Head.—Having selected dry lumber, proceed to build the pattern for the cylinder head as shown in Fig. 15 (*c*) and (*d*), remembering to allow stock for turning or finishing where the marks *f* and *p* appear on the drawing, Fig. 15 (*b*), *f* standing for finish and *p* for polish.

Before proceeding to build the pattern, a full-sized section of the head should be drawn in order to determine the thickness and number of courses needed. This drawing will also give the width of the courses necessary. In the case in hand, four courses have been selected, as shown at *a*, *b*, *c*, and *d*, Fig. 15 (*d*). After planing the lumber to an even thickness, and sawing out the segments for each course, it is well to stack them up crosswise and let them stand for several days in a dry place to season more fully.

37. In order to build up the pattern, a wooden face plate must be prepared, as shown at *g*, Fig. 15 (*c*) and (*d*). After this face plate has been built up and faced off in the lathe, the successive series of segments are built upon it, each segment being faced off in the lathe after it is in place, so as to insure a perfect bearing for the succeeding segment. After all the courses have been built up, a templet should be cut out, as shown at *t*, Fig. 15 (*d*). This templet may be made out of a board $\frac{1}{8}$ inch to $\frac{1}{4}$ inch thick, with the edges somewhat sharpened, or a thin sheet of metal, and the shape should be the same as the cross-section of the inside of the cylinder head. The small step on the face of the cylinder head, intended to receive the cover, should not be provided for in the pattern, as this can easily be turned in afterwards by the machinist. The inside of the pattern is turned out to correspond with the templet *t* and the outside of the segments *c* and *d* turned to the proper diameter, after which the pattern should be taken off from the face plate and the face *c* screwed to the face plate so as to permit the back side of the pattern to be turned. Care must be taken to center the outside of the segments *c* and *d* accurately. It will be seen by the dotted lines in Fig. 15 (*a*) that the grooves *a* do not extend entirely around the pattern, but in turning they are turned all the way around and the portion *g h*, Fig. 15 (*a*), is subsequently filled in.

38. After the pattern is turned, the ribs and the hub in the center must be made. The stock for the ribs is checked together as shown at *a*, Fig. 15 (*f*). Before half checking the pieces together, it may be well to roughly cut the ends to fit the templet *t*, after which care must be taken to see that, in half checking the pieces, they are joined exactly in the center, so that when the ribs are located as shown in Fig. 15 (*a*), the small boss will be exactly concentric with the head. The ribs should have a little taper to allow for draft, and should be made of such a height that the dimension *x*, in Fig. 15 (*b*), will correspond with that shown in Fig. 15 (*f*). Instead of gluing fillets into the corners at the base of the ribs after the latter are fastened in place, it is better to glue the fillets to the ribs, as shown in Fig. 15 (*f*). The hub at the center should also be formed by gluing corner pieces into the corners of the ribs, as shown, and turning a small hub to go on top of the pattern, as shown at *c*, Fig. 15 (*f*). After the ribs are completed, they are placed in the pattern, glued in position, and the fillets at the ends of the ribs made and glued into place.

39. Pattern for Cover.—The pattern for the false cover of the head is made as shown in plan and section in Fig. 15 (*e*). The plate is made of strips to prevent it from warping, and if the joints are not glued, the danger of the pattern cracking is greatly reduced. The strips are held together by two courses of segments, one on each side, as shown in the cross-section. Two small bosses *a* are turned and located in the center of the plate, as shown. The pieces for this pattern are gotten out in the usual manner and turned to proper form upon a wooden face plate. In the case of large engines, when very thin false covers are used, it is sometimes necessary to make the wooden pattern very carefully and to make a supporting form for it; then make one casting from this and finish it carefully so that it may be used as an iron pattern for all future castings that may be required. It is usually best to do this in the case of all large, thin castings. The supporting form for the wooden pattern may be so constructed as to fill all the space beneath the pattern, or it may be a frame supporting the pattern at frequent intervals.

PATTERN FOR DISK CRANK.

40. General Consideration of Casting Required. In Fig. 16 (*a*) are shown an elevation and two sections of a disk crank, one section being taken on the line *C D* and the other on the line *A B*. It will be noticed that the crank is provided with a counterbalance *d*, which is placed opposite the hub *e* for the crankpin. This hub *e* on small disks would be cast solid and the hole in it subsequently drilled and bored. The hub for the shaft *h* would always be cast with the hole cored through it.

41. Construction of Pattern for Disk Crank. The general construction of the pattern for this disk is shown in Fig. 16 (*b*), (*c*), and (*d*). The main web of the crank is composed of narrow boards, as shown in the elevation and section, Fig. 16 (*b*). These narrow strips *a* should not be glued together along their joints, but should be held in place by the segments *b* and *c* of which the rim is built up. After having built up the courses or segments of the plate, they should be allowed to dry for some time before turning, and, while this is going on, the counterbalance, hub, and crankpin hub may be made. It will be noticed in the sections shown in Fig. 16 (*a*) that the hubs project on one side of the crank. It is more convenient to make the projecting portion of the hubs separate, and hence the first pieces for the hubs are turned to the same thickness as the counterbalance, as shown at *a*, Fig. 16 (*c*).

After the hub is turned, one side is sawed off flat, as shown at *x*. This is a better way than fitting the counterbalance around the hub. The counterbalance is then carved out with its fillet in place and glued to the hub. After the hub and the counterbalance are fitted together as shown in Fig. 16 (*c*), the projecting portion of the hub is turned up, together with its core print, as shown in Fig. 16 (*d*). The hub *e* for the crankpin, Fig. 16 (*a*), is also turned up. The rib *i*, Fig. 16 (*a*), for connecting the shaft and crankpin hubs, need not be gotten out until it is necessary to attach the parts to the pattern. The portion of the hub *e* projecting beyond the rim of the pattern should also be made detachable and secured by dowel-pins. By the time these parts are completed, the segments for the main portion of the disk will be dry and this portion can

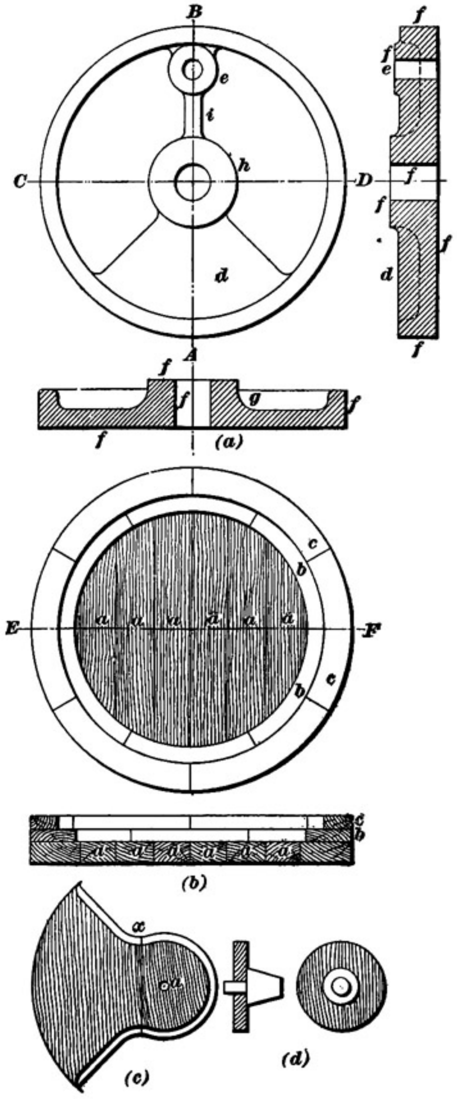


FIG. 16.

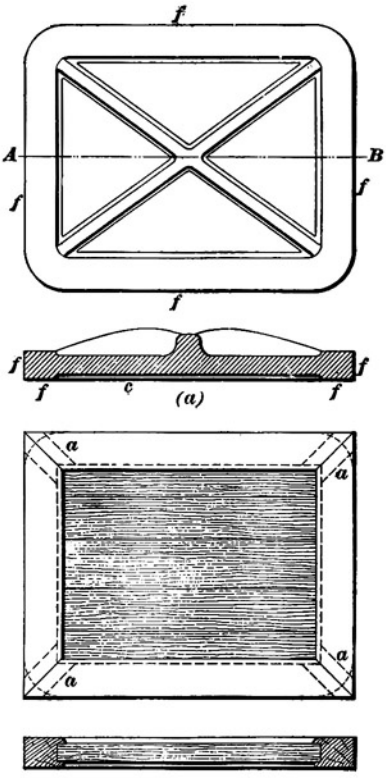
be screwed to the face plate of a lathe and turned up. In turning, the diameter should be made smaller on the plain side of the pattern for draft. The crank is molded in the position shown in the lower section, Fig. 16 (*a*), that is, with the hub up. The casting is made with this side up because the plain surface must be free from scum and dirt, in order that it may have a good smooth surface when machined.

42. Allowance for finish must be made on all the surfaces that are marked *f* in Fig. 16 (*a*). After the main portion of the disk is turned, the separate pieces are secured to it, care being taken to see that the grain in these portions runs in the same direction as the grain in the strips forming the web of the disk, as this will allow the parts to shrink uniformly. After the hub *h*, counterbalance *d*, and crankpin hub *e*, Fig. 16 (*a*), are in place, the web *i* and the fillets between the hub *e* and the outside of the disk are formed and glued in place. The reason for making the projecting portions of both hubs detachable is that this surface of the pattern may be placed in contact with the molding board during the first operation of molding.

PATTERN FOR STEAM-CHEST COVER.

43. General Consideration.—A steam-chest cover for a slide-valve engine is shown in Fig. 17 (*a*), the upper view being an elevation, and the lower one a section on the line *A B*. This cover is strengthened by cross-ribs in order to enable it to withstand the steam pressure to which it will be subjected. This is a very simple casting for which to make a pattern, and there is a number of ways in which it can be made. If it is desired to make it quickly, and make but one casting from it, a square piece of board with ribs and strips nailed on the outer edges will answer the purpose, but this will not do for a pattern in frequent use, because it will probably split and warp out of shape. When the pattern is intended for continuous use, it is better to build it up of separate pieces.

44. Construction of a Pattern for Steam-Chest Cover.—Fig. 17 (*b*) shows two views of a partially completed pattern for a steam-chest cover, the upper one being an elevation and the lower one a section. The central part, or web, is made up of narrow strips, as in the case of the pattern of the disk crank. These strips are fitted into a groove in the outer frame surrounding them. It will be noticed that this frame is mitered at the corners and joined together by tongues, as indicated by the dotted lines at *a*. The pattern is molded and the casting poured with the side that is to go next to the cylinder, down, that is, the side *c*, Fig. 17 (*a*). This is done to insure clean iron on this surface, because it is to be planed. Stock must be left to allow for finish on all the surfaces marked *f*, Fig. 17 (*a*). The four corners of the pattern are rounded, as indicated by the dotted lines, Fig. 17 (*b*), after which the cross-ribs are made by joining two pieces together at the center and cutting them to the desired form. These ribs should be doweled to the cover so that they may be taken off to allow the molder to lay the pattern flat on the board during the first operation in molding. The construction of the ribs is very simple, and hence they are not shown in the illustration.



(*b*)

FIG. 17.

PATTERNS FOR CORLISS ENGINE VALVE-GEAR DETAILS.

45. General Consideration of Castings.—Fig. 18 shows two views of a hook lever for a Corliss engine valve gear and Fig. 19 (*a*) shows two views of an exhaust arm for the Corliss engine. The two castings have very similar characteristics, that is, each is composed of one or more flat levers having an oval cross-section and bosses or hubs at the ends. The exhaust arm shown in Fig. 19 (*a*) is the simpler of the two, and hence its construction will be taken up first.

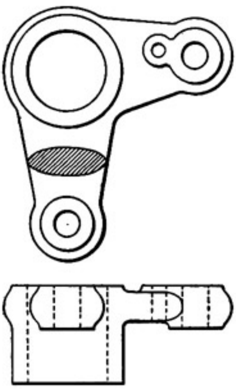


FIG. 18.

46. Pattern for Exhaust Arm. A piece of wood is planed parallel on its sides to the thickness *a*, Fig. 19 (*a*), and, after the outline of the arm is laid out upon it, it is carefully sawed out with a narrow band saw to the shape shown in Fig. 19 (*b*). After this, two $\frac{3}{4}$-inch holes are bored through the pattern, one at the center of each hub. Care should be taken to see that these holes are perpendicular to the surface of the block and parallel to each other, so that the distance from center to center shall be the same on both sides. After these holes have been bored, the four small bosses *a*, *b*, *c*, and *d*, Fig. 19 (*c*), are turned as shown.

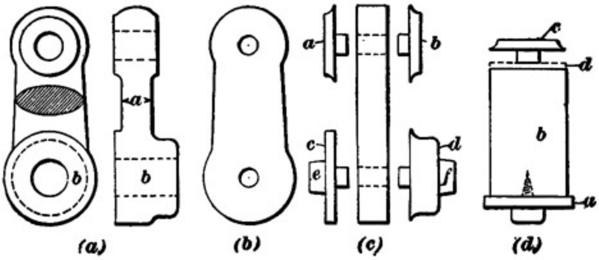


FIG. 19.

These bosses are provided with pins that fit tightly into the holes bored in the arm. Owing to the fact that the larger end *b*, Fig. 19 (*a*), contains much more metal than the smaller end, it is necessary to make provision for cooling it as rapidly as possible, in order to prevent the smaller portion from drawing metal from it as it cools. This is accomplished by coring a hole through the larger end, the hole through the smaller end being drilled through the solid metal after the casting is completed. To provide for this core, two core prints *e* and *f* are provided on the bosses *c* and *d*, Fig. 19 (*c*).

47. To turn the bosses for this pattern, first saw out, from a thick plank, a rough piece large enough in diameter to turn the largest boss, and screw it to the screw chuck of the lathe, as shown in Fig. 19 (*d*), *a* being the screw chuck and *b* the block. In this way, the bosses may be turned and cut off with a narrow cutting-off chisel. One completed boss is shown at *c*, and the dotted lines at *d* represent the amount removed by the parting chisel. The grain in this piece should run crosswise and not in the direction of the center line of the boss, as the latter arrangement would make it difficult to turn the fillets without breaking their outer edges. When the bosses are completed, they are glued in place on each side of the arm, care being taken to locate them so that the grain of the wood in the bosses and the arm runs in the same direction. The arm is next worked to an oval shape between the bosses, as shown in Fig. 19 (*a*). The corners should be carved carefully to size. Sandpaper should be used only for the final finishing; it is not good practice to do with sandpaper what should be done with tools. As shown in the illustration, this pattern is made solid or without a parting line. When many castings are required, it is well to make a match of oil sand or plaster, or metal patterns may be made in halves.

48. Pattern for Hook Lever.—The pattern for the hook lever shown in Fig. 18 is made in the same manner as that for the exhaust arm, except that the plate forming the two arms is made in two pieces and fastened together with a tongue, as shown in Fig. 20. In this case, the bosses will serve to hold the joint together when glued on each side.

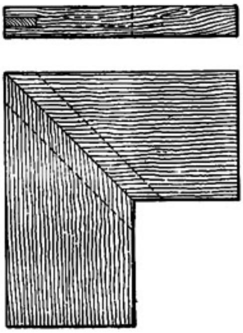


FIG. 20.

PATTERN FOR SLIDE-VALVE ENGINE CYLINDER.

49. Construction of Cylinder. Slide-valve engine cylinders are made in a variety of forms. The one chosen and explained here is of a well-known type and is illustrated by the three views shown in Fig. 21, (*a*) being a longitudinal section through the cylinder, steam chest, and ports, (*b*) a section on the line *A B* showing the exhaust port, and (*c*) a section on the line *C D* showing the steam port and steam chest. From this it will be seen that quite a complicated system of coring is necessary.

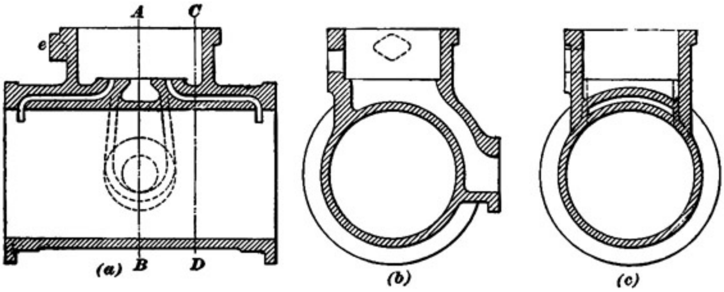


FIG. 21.

50. Pattern for the Cylinder.—The making of the pattern for this cylinder depends largely on its size. When the diameter is to be less than 12 inches, the body may be built up solid, but, when above that size, and is intended for constant use, it is better to build it with staves, as shown in Fig. 22 (*a*) and (*b*). In this case, only one-half of the pattern is shown, as that is all that will be needed for explanation.

For the cheaper grades of patterns the body of the cylinder may be built up as shown in Fig. 22 (*a*), the stave supports, or heads, *a* being sawed out in the form of polygons to receive the staves *b*. The supports *a* should be built up and the sections so placed that the grain of the wood runs approximately in the direction of the circumference of the cylinder, as shown in Fig. 22 (*c*), for if made of single pieces, they will shrink across the grain and cause one diameter of the cylinder to be reduced more than the other.

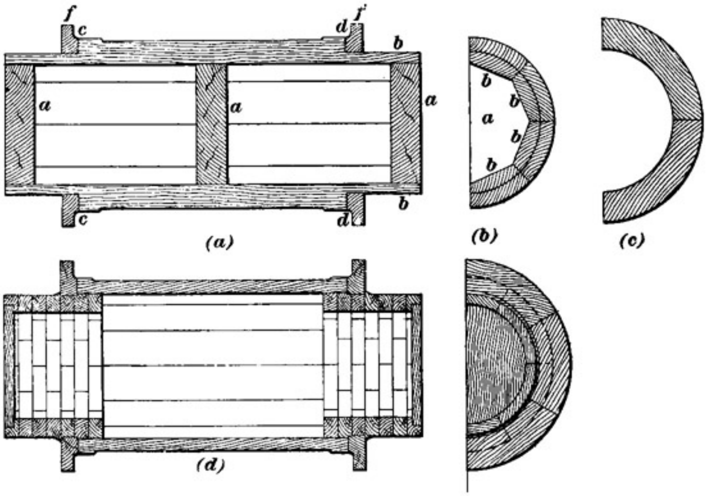
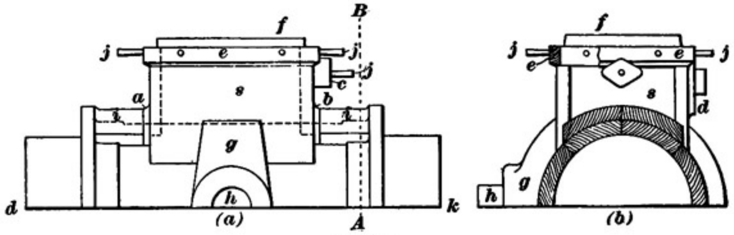


FIG. 22.

The staves are so placed that the core prints at the ends of the pattern can be turned from them. This method makes a stronger pattern than can be formed by fastening the prints on the ends with screws or glue. The flanges *f* are made thick enough so that the fillets on the back can be turned from the stock of the flanges. The flanges should be made with the grain running diagonally, as shown in Fig. 22 (*c*), as this method of placing the wood will prevent the shrinkage from affecting the flanges to any great extent.

The better grades of patterns are made as explained in *Patternmaking*, Part 2, the stave supports and core prints being built up as shown in Fig. 22 (*b*). The flanges may be built of segments, of one thickness of stock, as shown, or of two or three thicknesses, with staggered joints, depending on the intended use of the pattern.

51. The cylinder body is built up and turned before the steam chest is made and fitted. The steam chest is then fitted on as shown in Fig. 23 (*a*) and (*b*). Only one half of the pattern will have to be fitted with the steam chest, the other half simply requiring one-half of the flange and core print for the exhaust port, as shown at *h*. The pieces for the exhaust passage *g* and thickness *i* over the steam ports are shown in place; they must be carved out of wood and glued and screwed to the pattern. The fillets at *a* and *b*, Fig. 23 (*a*), are cut out from solid blocks that are placed between the pieces *i* and the steam chest proper; this prevents all danger of the fillets coming out or being stripped from the pattern. The steam chest *s* may be made solid or it may be built up as a box, the construction depending on its size. The strips *e* on the steam chest, which give extra thickness of metal for the studs, are made loose, being held in place during molding by long dowel-pins *j*. Also, the valve-stem stuffingbox *c* and the facing *d* around the live-steam opening are loose and fastened in the same way. In Fig. 23 (*b*), a portion of the strip *e* has been broken away to show the manner of letting it into the pattern. This is to prevent its being moved out of place during ramming, after the dowel-pins have been taken out.

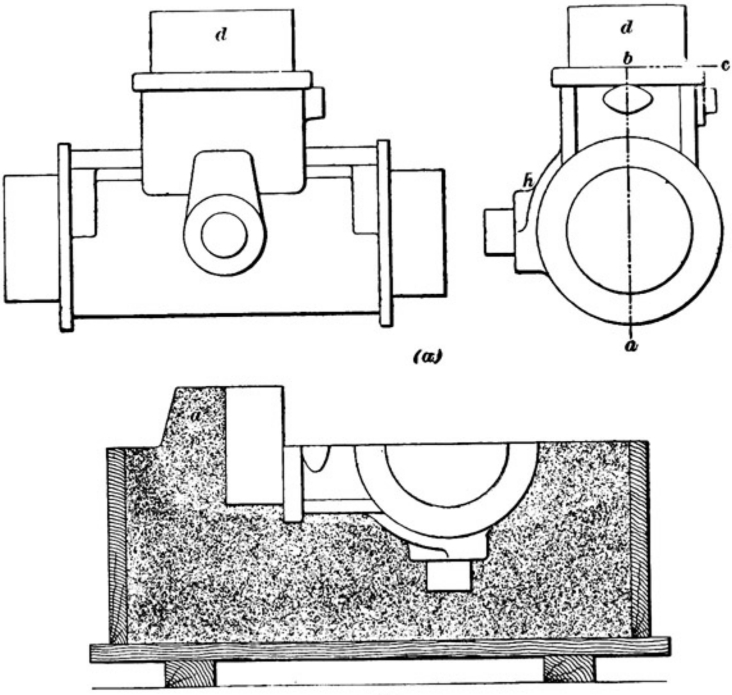


(a) (b)

FIG. 23.

52. This pattern is molded in a two-part flask, parted on the line *dk*, all the loose pieces mentioned being made in sections and so placed that the main pattern will draw away and leave them in the sand. They can then be drawn into the opening left by the pattern and removed, one piece at a time. The core print *f* for the steam chest should be doweled on also; because if made fast, the molder will probably tear it off, as it is a great convenience to have this print loose so that it can be placed back in the bottom of the mold while drawing the loose pieces and dressing up the mold.

Another method of making a cylinder pattern is shown in Fig. 24 (*a*). The pattern is in this case parted along the



(*a*)

(*b*)

FIG. 24.

line *a*, *b*, *c*, and the core print *d*, for the steam chest is attached to the lower half of the pattern. This method will enable all the parts of the steam chest to be fixed rigidly to the pattern, will make the setting of the cores easier, and the expense of making both the pattern and the mold will be somewhat smaller and they can be made in less time. It has the disadvantage of not having the valve face at the bottom of the mold, where the best iron is obtained, and for this reason it is not generally adopted. It is, however, sometimes used for repair or other emergency work, where the casting must be made in the shortest possible time.

With this pattern the mold must be made with the half to which the steam-chest core print is attached, in the lower half, commonly called the *drag*, or *nowel*. A sand pillar *a* must be built up as shown in Fig. 24 (*b*), so as to permit the core, which is made solid, to be set in place, and to avoid the danger of injuring the mold in closing it. The core print must be made quite long, in order to furnish a good support for the core.

53. Core Boxes for Cylinders.—The core box for the steam ports of the pattern shown in Fig. 23 is shown in Fig. 25 (*a*), with the side *a*, Fig. 25 (*c*), removed. The core is swept up on the outside along the length marked *x*, a special sweep being provided for this purpose, which is guided by the sides *a* and *b*, Fig. 25 (*b*) and (*c*). The piece *c* is made to form the upper part of the core, because it changes from a circular shape to a straight part just where it enters the steam chest. Fig. 25 (*b*) is a top view, and Fig. 25 (*c*) is an end view of the box with the end *d*, Fig. 25 (*a*), removed.

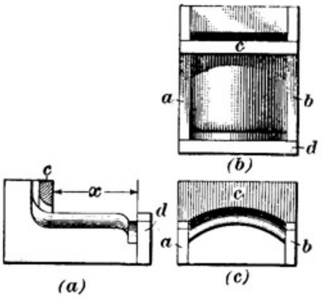


FIG. 25.

54. The exhaust-port core box is made in halves, and one half is shown in Fig. 26, the other half being like this, except that it is made left-handed, so that the two halves will fit when put together. The dotted line in Fig. 26 (*a*) shows how the passage is widened to maintain a constant area throughout, that is, it is cut down along the part of the passage occupied by the arrow in Fig. 26 (*b*).

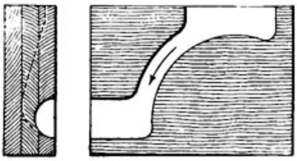
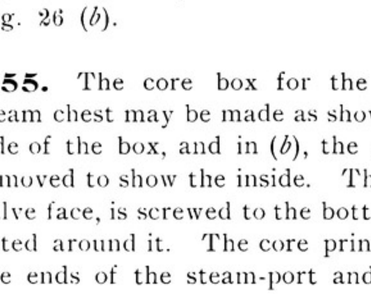

(*a*) (*b*)

FIG. 26.

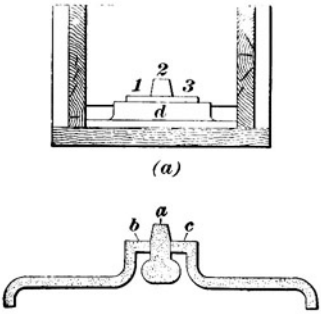
55. The core box for the steam chest may be made as shown in Fig. 27. In (*a*), the side of the box, and in (*b*), the end of the box, have been removed to show the inside. The piece *d*, which forms the valve face, is screwed to the bottom of the box and the sides fitted around it. The core prints *1*, *2*, and *3* are to receive the ends of the steam-port and exhaust-port cores. The steam-chest core is the first that is set in the mold, the cylinder being molded with the steam chest down. After this, the exhaust-port and steam-port cores are set with their ends in the openings left by the prints *1*, *2*, and *3*, Fig. 27. The core for the cylinder body is usually swept up on an iron cylinder wrapped with hay rope, the prints to receive the ends of the steam-port cores being formed in the core.



(*a*) (*b*) (*c*)

FIG. 27.

In the case of small cylinders, the prints for the end of the port cores, as shown at *1*, *2*, and *3*, Fig. 27, are frequently made of the form shown in Fig. 28 (*a*), and the cores for the steam ports are provided with projections to fill the space between the steam-port print and the exhaust-port print. The general form of the cores is shown by Fig. 28(*b*), in which *a* is the exhaust-port core print and *b* and *c* the projections on the end of the steam-port cores. When this method is employed, the core box shown in Fig. 25 is made in such a manner as to provide for the projections on the cores as shown at *b* and *c*, Fig. 28 (*b*).



(*a*)

(*b*)

FIG. 28.

56. It is possible to make the mold with a half-cylinder pattern, by making all the parts for the steam chest, port passages, etc. detachable, and arranging the pattern so that only the portion for the print *h*, Fig. 23, and the flange that surrounds it will be used in molding the second half. It will, of course, be necessary to place these on the opposite side of the pattern, so that both halves will come together properly. When this is done, each half of the mold can be made separately and then put together. Patterns for Corliss engine cylinders may be constructed in a similar manner.

PATTERNMAKING.

(PART 4.)

PRACTICAL EXAMPLES OF PATTERNMAKING.

STOP OR THROTTLE VALVE.

1. General Consideration of the Castings Required.—A **stop,** or **throttle, valve** is shown in section

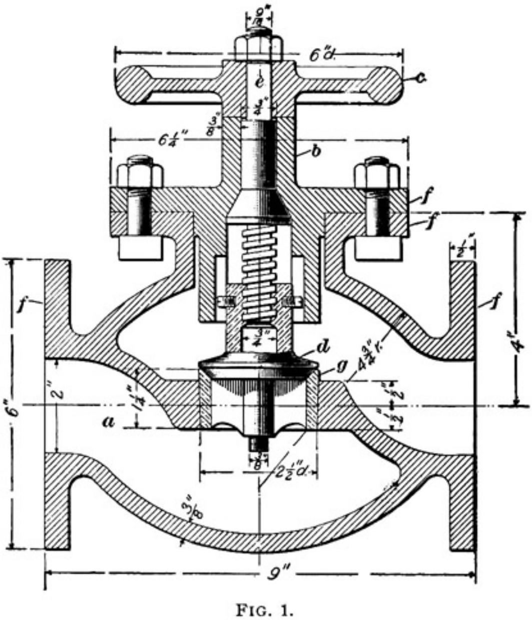


FIG. 1.

in Fig. 1. The body *a*, the bonnet *b*, and the hand wheel *c*

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are all made of cast iron, while the valve *d*, valve stem *e*, and seat *g* are made of brass. Finish must be allowed for all joints and for all faces marked *f*.

2. Pattern for Valve Body.—This throttle valve is similar to the ordinary globe valve shown in Fig. 4,

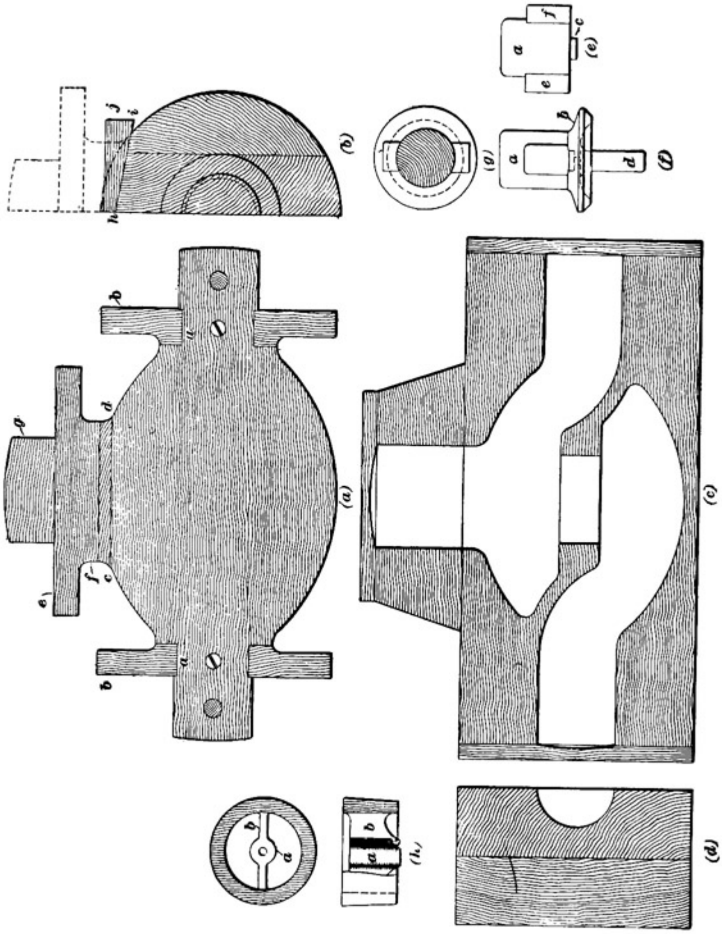


FIG. 2.

Patternmaking, Part 3, but is made of cast iron, and the patterns for it differ somewhat in construction from the globe-valve pattern. Fig. 2 (*a*) shows one-half of the pattern and illustrates the method of joining the different parts. The stock for the main portion of the valve should be sawed out about 16 inches long, which will allow about 1¾ inches on each end for screwing the halves together while turning. The halves of this pattern should not be glued together, as they must be taken apart and put together again before the turning is finished. The end flanges fit in recesses formed in the core prints, as shown at *a*, Fig. 2 (*a*). The flanges *b*, Fig. 2 (*a*), are turned on the pattern, that is, they are first bored and faced to fit the recesses in the core prints, after which they are screwed and glued in place and then turned up or finished during the work of finishing the valve body. This insures their being concentric with the body of the pattern. The body should be turned to a templet cut to a 4¾-inch radius.

Owing to the fact that the body is oval and not round, the side flange *e*, together with the portion of the pattern connecting it to the body, has to be joined in a special manner. If a flat surface were formed on one side of the body of the pattern, it would have an oval outline; hence, the surface must be formed in such a manner as to have a circular outline. This is accomplished by cutting the faces of the halves of the pattern at an angle, as seen in the end view, Fig. 2 (*b*), which shows the pattern with the flange *b* removed. Two wedge-shaped blocks *j* are fitted to the pattern, being joined along the line *h i*, Fig. 2 (*b*), and along the line *c d*, Fig. 2 (*a*). Upon the back of these blocks *j*, the flange *e* and the portion *f* joining it to the pattern are secured, they having previously been turned. After this, the necessary fillets are worked out of the wedges *j*, Fig. 2 (*b*), the form of the half pattern when completed being indicated by the dotted lines. In the illustration, the core print *g* is represented as being simply glued and screwed to the flange *e*.

3. Core Box for Valve Body.—One-half of the core box for the valve body is shown in Fig. 2 (*c*) and an end view with the end board removed and the side projection omitted is shown at Fig. 2 (*d*). From this it will be seen that the core box is built up from two or more flat pieces glued together. In the illustration, the separating bridge is shown as being carved out of the piece forming the core

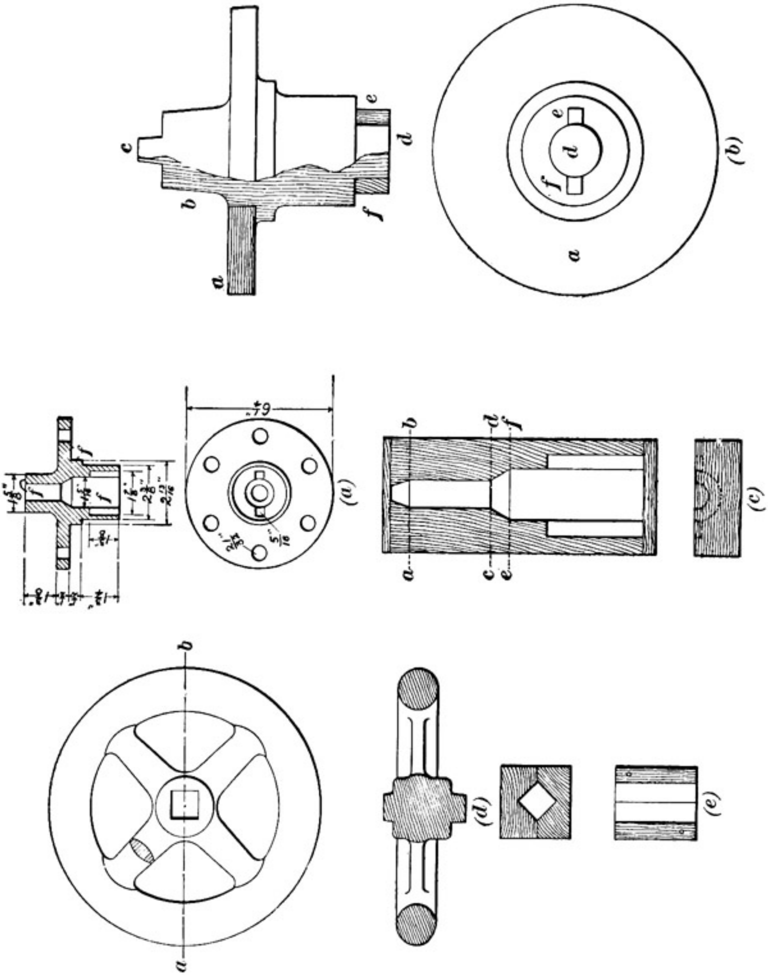


FIG. 3.

box. This bridge is cut down almost perpendicular to the surface of the box, very little draft being allowed on the sides and a small fillet being made at the bottom. It will be seen that in order that the cores may match when pasted together, another half box is needed. One half is, however, sometimes made to answer by making two separating bridges, one right-handed and one left-handed, which are doweled in place, so that, when the cores are being made, the bridges are used alternately. This apparently accomplishes the same purpose as two completed half core boxes, but in practice it does not give the same satisfaction, as the bridges are liable to be broken, lost, or rammed out of place when making cores, resulting in an imperfect casting, and, as this kind of pattern is liable to be used constantly, it will be more serviceable to make two complete half boxes with bridges as represented. The ends and side of the box are closed with boards, as shown, the necessary draft being formed in these boards for the ends of the cores. For carving such a box, it will be necessary to make templets for the various cross-sections.

4. Bonnet Pattern.—A detail of the bonnet casting is shown in Fig. 3 (*a*) and the pattern is shown in plan and elevation at Fig. 3 (*b*). The upper view shows an elevation of the pattern, a portion of which has been broken away to illustrate the construction. The pattern is drawn to a larger scale than the casting. The flange *a* for the pattern is turned after it is fitted and fastened to the main portion of the pattern. As shown in the illustration, this pattern is not parted and is made to mold endwise. It will be necessary to have a molding board with a hole in the center for the portion *b* to project through during the first operation of molding. The main body of the pattern, including the core print *c* and the cylindrical portion of the print *d*, is turned from one piece. The auxiliary core prints *e* and *f* are glued and screwed in place.

5. Core Box for Bonnet Casting.—A core box for the bonnet pattern is illustrated by the two views shown in Fig. 3 (*c*). This pattern can all be carved from one block of wood, with end boards as shown. The proper draft must be allowed on the inside of the end boards. The core box can be made from several pieces with divisions along the dotted lines *a b*, *c d*, and *e f*. This latter construction will permit the turning or working out of each portion of the box separately, which will somewhat simplify the construction, though, in most cases, the large number of joints adds complications that more than overbalance the gain. When the box is made of separate pieces, the various pieces are secured in place by gluing a board on the back of the box.

6. Pattern and Core Box for Hand Wheel.—The pattern for the hand wheel is shown in the two views given in Fig. 3 (*d*), the lower one being a section on the line *a b*. The pattern being only 6 inches in diameter may be turned from one solid piece of wood, but, when forming the arms, care should be taken to cut them so that the grain of the wood runs at an angle of 45° to the arms, which will make them of uniform strength. Another way is to turn the rim from a single piece and then let the arms into it. Square core prints are formed on the pattern, as shown in the illustration. The core prints are turned to a diameter equal to the diameter across the corners of the squares, and are subsequently cut to a square form.

The square core box for the hand-wheel core is illustrated in Fig. 3 (*e*); it is made in halves and doweled together, being parted at the two corners, so that when the core is rammed up, the box can easily be taken apart without breaking the corners of the core.

7. Patterns for Valve Details.—The pattern for the valve is shown in Fig. 2 (*e*), (*f*), and (*g*). The upper, or nut, part of the valve pattern *a* is not made fast to the valve *b*, but is located by a ½-inch pin *c* that is turned on it, as shown in Fig. 2 (*e*). The guide *d* is made in the same manner, but is secured permanently to the valve pattern, as shown in Fig. 2 (*f*). The pieces *e* and *f* are glued and screwed to the piece *a* after the latter has been turned.

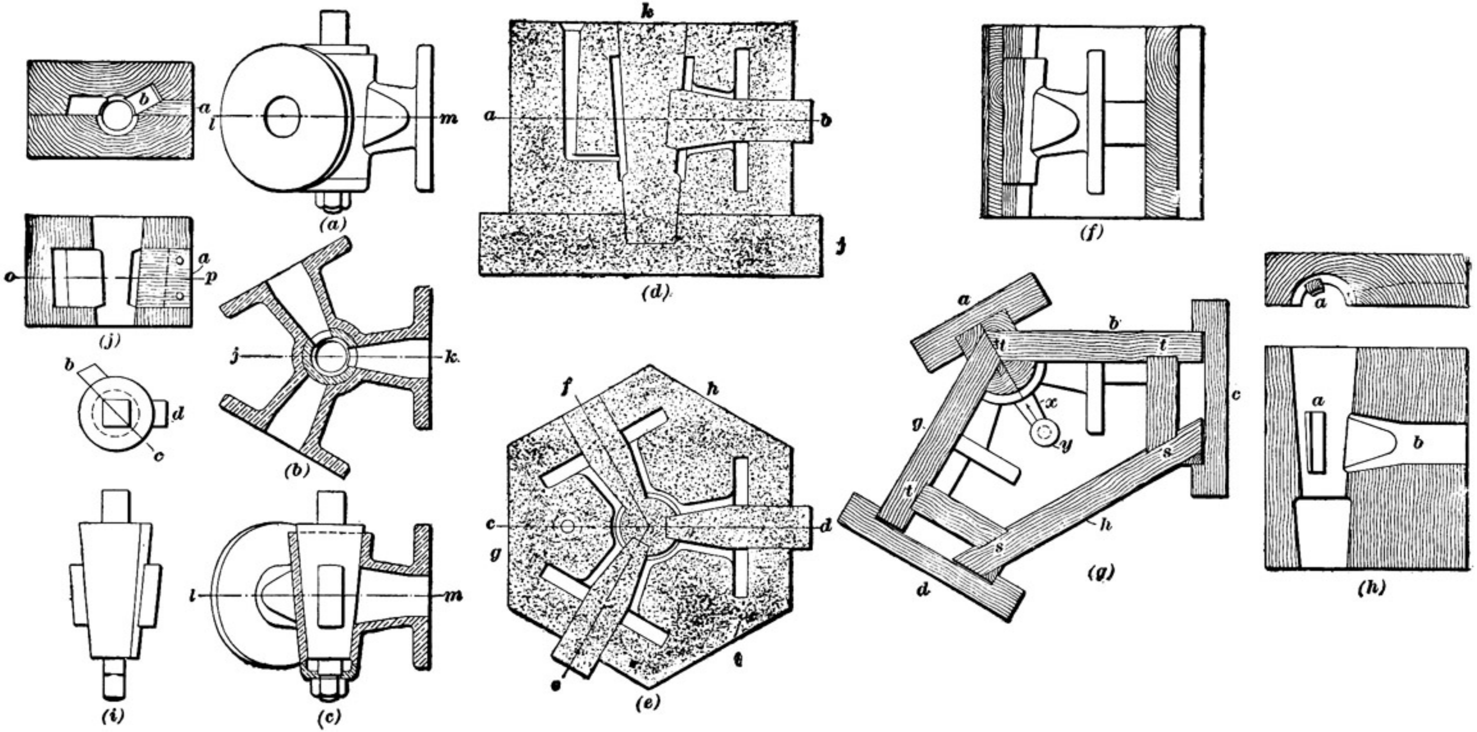
The pattern for the valve seat is shown by the two views given in Fig. 2 (*h*). In the lower view, a portion of the pattern has been broken away so as to show the hub, or guide, *a* for the spindle on the lower portion of the valve. This hub is supported by the web *b*, as shown. The grain in this pattern should run in the direction of the axis of the seat, as indicated by the lower view. The outer ring of this pattern may be turned from a block of wood and the bridge *b* and hub *a* glued in place afterwards..

No pattern is shown for the valve spindle, as it will be similar to the one shown in *Patternmaking*, Part 3. The valve seat, valve, and spindle are made of brass, and it is therefore not necessary to allow as much stock for finish on the pattern as in the case of iron castings, owing to the fact that brass castings are usually smoother.

SPECIAL THREE-WAY STOP-COCK.

8. Construction.—The three-way stop-cock described in *Patternmaking*, Part 3, is of such construction that all the angles are right angles. The one illustrated in Fig. 4 is a special design, having the three passages 120° apart. The general construction of the valve will be understood by reference to Fig. 4 (*a*), (*b*), and (*c*). Fig. 4 (*a*) is an elevation of a complete cock; (*b*) is a section on the line *l m*; while (*c*) is a section on the line *j k*. In Fig. 4 (*c*) the cock is not shown as it would appear if projected from (*b*); the plug has, however, been given a portion of a revolution so as to bring one of the openings to the front. Owing to the shape of this design of cock, it cannot be molded and cast like the one shown in *Patternmaking*, Part 3.

9. Appliances for Dry-Sand Mold for Body.—For a straight-way cock there is no better way of obtaining a casting than by making a pattern; but for a three-way body or shell of the design shown, a core box may be substituted for the pattern and made to answer the molder's requirements better than the pattern. The disadvantages of a pattern for the shell arise from the fact that it is practically impossible to part the pattern in such a direction that it can be molded in any but a complicated flask.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(h)

FIG. 4.

10. Fig. 4 (*d*) is a vertical section of a mold for such a valve body, and Fig. 4 (*e*) is a horizontal section of the same mold. The outer part of this mold consists of three cores *g*, *h*, and *i*. These cores are joined on the radial lines passing through the points *d*, *e*, and *f*. The center and passage cores on the line passing through the point *f* are made in one piece. The passage cores on the lines passing through *d* and *e* are made separate from and set into the center core. The three cores *g*, *h*, and *i* rest upon the slab core *j*, shown in Fig. 4 (*d*) but omitted in the plan in Fig. 4 (*e*). When locating the cores, the center core *k* is first set into the slab core *j*, as shown in Fig. 4 (*d*), then the cores *g* and *h* are set. These, being joined at *f*, will support the passage core on that center line. Before core *i* is set, the cores on the lines *e* and *d* are located. The ends of these cores are made to project so that the molder may either block up the ends or have a helper hold them while setting the core *i*. When all the cores have been properly set, a flask is dropped over them and sand rammed about them to keep them in place.

The core box for making the cores *g*, *h*, and *i* is shown in Fig. 4 (*f*) and (*g*). In Fig. 4 (*f*), the portions *g* and *h* of the core box have been removed, only the portion *b* being shown in place. The joints at *t*, *t* are left loose while the joints at *s*, *s* are secured by glue and screws. The parts of the box *b*, *g*, and *h* are secured together by clamps *a*, *c*, and *d*, so that, after the core is completed, the clamps may be removed and the different parts of the box drawn away from about the core, thus leaving it standing upon the core plate. The gate shown is used for only one core; *x* is separate from *y* and is drawn out in the direction of the arrow, when all the parts of the box have been taken away from the core.

11. The core box for making the center *k* and the passage core on the line *f*, Fig. 4 (*d*) and (*e*), is shown in the two views given at Fig. 4 (*h*). The print *a* must either be given sufficient draft to allow the core to be drawn away from it, or it must be so arranged that it can be drawn out of the core through the back of the core box. Another half box to match the one shown will be necessary in order to make a complete core, or a wide box may be made having provision for two projecting arms *b*, either one of which can be stopped off at will. When this is done, it will also be necessary to construct the core print *a* so that it can be changed from one side to the other. On the whole, it is usually best to construct the two half boxes.

The core box for the passage cores on the lines *d* and *e* is not shown, as it is very simple in construction and similar to others that have already been described. Its general form is very similar to the portion *b* of the core box shown in Fig. 4 (*h*), only it will be necessary to make the box longer so as to allow the cores to project as shown in Fig. 4 (*e*).

12. Pattern for Plug.—The plug for the three-way cock has only two openings placed at an angle that coincides with the two passages of the shell, which are 120° apart. The thickness of the metal in the plug is the same as that in the shell. To make this casting, a pattern is used, though it can be made all together with cores like the shell, but a pattern in this case is probably the better method. The pattern is shown in the two views given in Fig. 4 (*i*). The pattern is parted on the line *b c* shown in the upper view. It will be seen that the core print *d* would not draw if fastened to the pattern. It should therefore be located with loose pins or wires that can be withdrawn during the process of molding, leaving the piece loose in the sand. After the pattern is withdrawn, this piece can be withdrawn also. In some cases, a section of one-half of the pattern may be arranged to be drawn separately and at an angle so that the print can be attached to it.

13. Core Box for the Plug.—The core box is made as shown in the two views Fig. 4 (*j*), the piece *a* being put on with two pins and held in place by means of a screw or clamp while making the core. After the core is complete, the piece *a* is removed so as to allow the finished core to be turned out. If the upper half of the core shown in the upper view Fig. 4 (*j*) were being dried by itself, the core maker would place a little green sand between the core plate and the projecting portion *b* so as to support it during drying. In the illustration, the lower view shows one-half of the core box, while the upper view shows the entire core box, both halves having been made. The core can be made in halves or in one piece, depending on the manner in which it is to be dried.

PATTERN FOR SMALL BELL.

14. General Consideration.—Molds for large bells are swept up in loam, but for small bells of such dimensions as that shown in Fig. 5, patterns are usually made. This also applies to any similar shape, such as ladles, kettles, pots, etc. In some cases the patterns are made for relatively large castings, especially when the metal of the casting is comparatively thick, as, for instance, slag pots for copper and lead smelters are usually cast from patterns, the castings weighing from 400 to 600 pounds, some of them being as much as 30 inches in diameter. The bell shown in Fig. 5 would be cast from bronze or bell metal and the nut *a* from brass or iron. The washer *b* might be cast from brass or made from sheet metal.

15. Making Pattern for Bell.—The right-hand side of the bell, Fig. 5, is shown in section so as to illustrate the thickness of the metal and the method of laying out the pattern. From the point *g*, on the upper corner of the bell, to *h*, at the edge, a straight line is drawn and divided into equal spaces. From each of these points, perpendicular lines are drawn and on each of these perpendicular lines a circle is laid off that represents the thickness of the bell at the point where the line intersects it. The distance on these perpendicular lines from the straight line to the center of the circle is carefully determined. This information is generally furnished on the drawing for the bell. The patternmaker lays out these lines, circles, and the outline of the bell to full size, and thus determines the thickness of the courses or segments as shown on the left-hand side. As shown, the first four courses are $\frac{3}{4}$ inch thick and all the others $\frac{1}{2}$ inch. The sizes of segments and the number required are given at the right of the illustration. The proper allowance has been made for turning after the segments are in place. The segments marked *10* are for six courses and those marked *9* for three courses, each course being made up of six segments. In each of the other courses the segments are different.

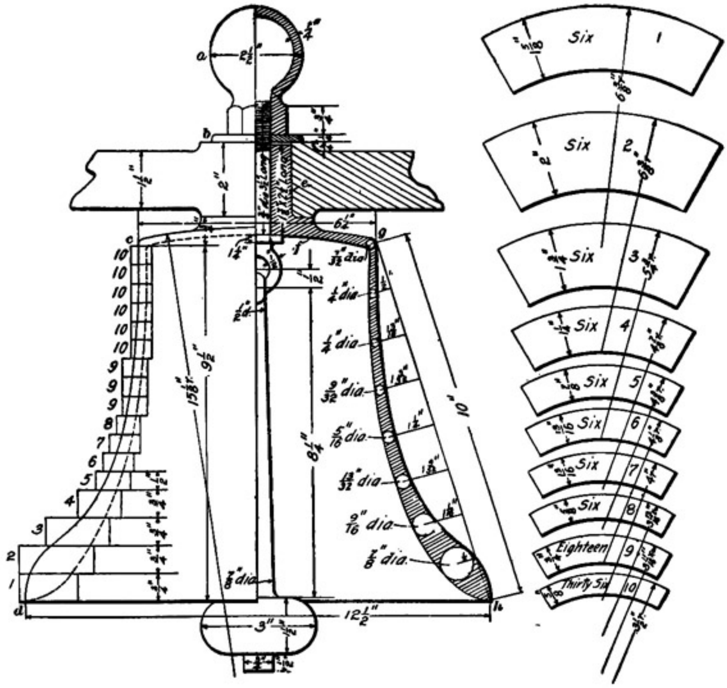

FIG. 5.

16. After the segments are sawed out, they should be stacked up crosswise and allowed to dry thoroughly before being built up. When they are dry, the part that forms the top of the bell is cut to a circular form from a well-seasoned solid piece, enough stock being allowed for finish. It is then screwed to a face plate, the front faced off, and the part that forms the inside of the top turned hollow, as shown at *f*.

The segments marked *10* are glued on, one by one, until as great a distance as can conveniently be turned out on the inside is reached. The glue is then allowed to set, and the inside turned out to the required form. Other segments are now added until another suitable depth for turning is reached, and the turning done as before. This operation is repeated until the entire body of the bell is built up and turned on the inside. The outside is also turned a short distance from the edge *d h*, as shown in Fig. 6. The pattern is then detached from the face plate and a chuck *a*, Fig. 6, turned to receive the turned part of the outside, and the pattern inserted and fastened with screws, two of which are shown at *b* and *c*. The outside is now turned to the required form, which is indicated by the dotted lines.

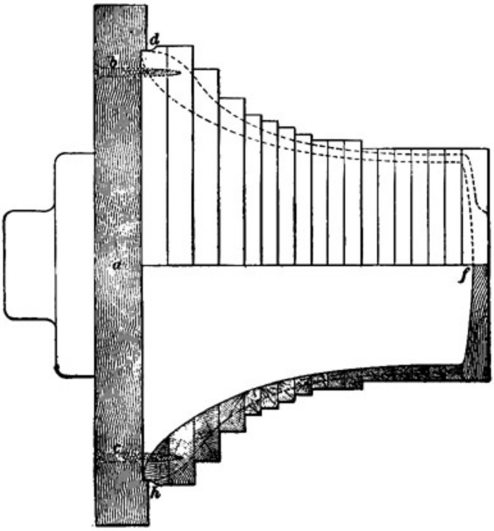

FIG. 6.

17. In building up the body of the pattern, the different courses must be faced off to the required thickness, and measurements must be made from the back of the bell to the front of the segments at frequent intervals, in order that the succeeding courses may occupy their correct positions in the pattern. If the different courses are allowed to remain too thick, the larger courses may be carried forward so far that the required form cannot be obtained.

When passing from a smaller to a larger course in building up the pattern, it is necessary to scribe a circle on the smaller one, the diameter of which is equal to the inside diameter of the larger course, to which the larger course may be set. This circle may be drawn either by placing a temporary piece of wood across the partially made pattern, for the purpose of providing a center for the dividers, which are set to the radius of the required circle, or by setting trammels to the diameter of the circle and holding them so that the two points stand diametrically opposite each other and will scribe a single circle while the work is revolving. The spindle *e*, Fig. 5, should be glued on after the pattern is turned, in a manner similar to a core print, a pin on the spindle fitting into a hole turned in the top of the pattern.

18. When turning any pattern from built-up stock that requires finishing both on the inside and the outside, it is usually best to finish the inside first, on account of the fact that the pattern is always stronger to resist injury from the outside than from the inside, and hence if the inside were turned last, there would be danger of breaking out some of the segments.

19. The patterns for the nut *a* and the washer *b* are so simple that they need not be illustrated. The pattern for the nut would be parted through the center line, and must be made with a long core print for supporting the core, similar to the pattern shown in Fig. 10, *Patternmaking*, Part 1.

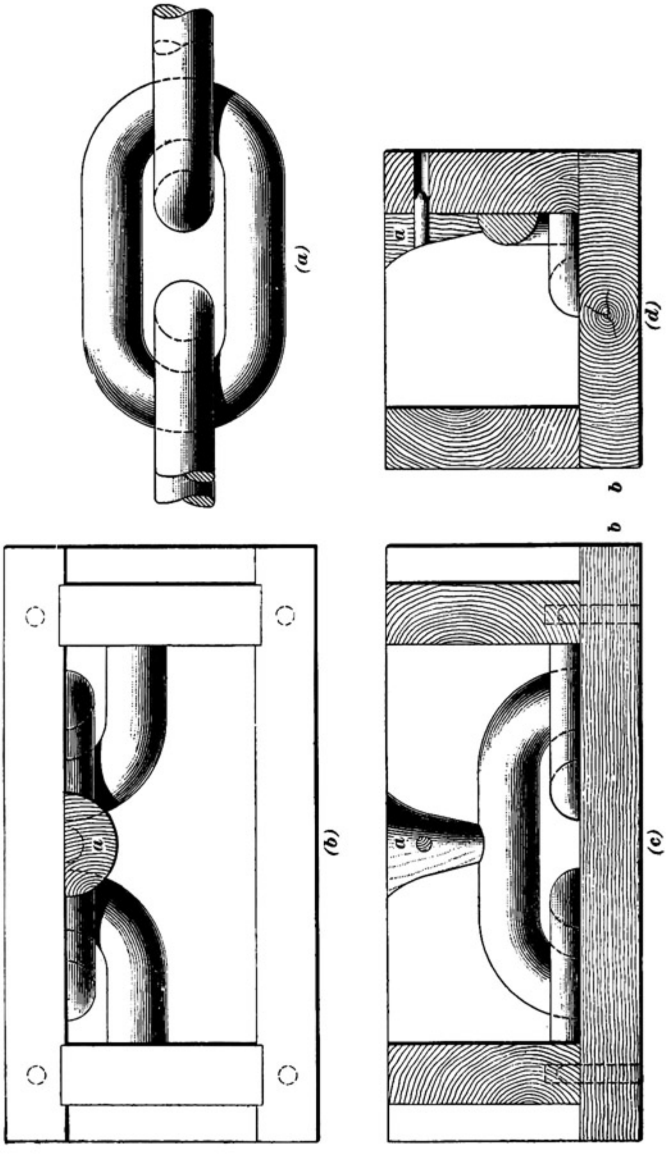

FIG. 7.

PATTERNS AND CORE BOX FOR CASTING CHAIN.

20. A chain is sometimes cast of strong bronze for marine or other purposes, especially where iron would corrode excessively, but such chains are so costly that they will never be generally used. One link and the connections to the two adjacent links of a chain are shown in Fig. 7 (*a*). Each link passes through two others, and hence the mold for casting the entire chain at once would be very complicated, as would also the system of gating. To overcome this, one-half of the links may be cast separately and then provision made for casting the other links through these.

21. Patterns for Links.—In constructing the link pattern, wood is used for the first pattern, a double allowance for shrinkage being made. The pattern need not be parted, but may be cut from a solid piece of wood. The allowances for shrinkage should be one for aluminum ($\frac{1}{4}$ inch to the foot) and one for bronze ($\frac{3}{16}$ inch to the foot). In making the link, its form is first marked out and cut to a square cross-section inside and out. Then the edges are chamfered to a 45° line tangent to the circle of stock in the link, after which it can be cut round.

This pattern could also be made by turning a ring with the radius equal to the radius of the end of the link, cutting it in halves for the ends and then joining these half rings by two straight cylindrical pieces to form the sides of the links, but there is much less work in the first method than in the second, because the turning and fitting take more time, and then, too, the pattern made by the second method is not as strong as the one cut from a solid piece of wood.

Four or more aluminum patterns are now cast from the wooden one and made smooth, after which they are sunk one-half of their depth into the molding board and a gate fastened on the latter. This simple provision allows several links to be molded at once. At times, the links are split and attached to the opposite sides of a card pattern owing to the fact that one-half of all the links of the chain must be cast in this way and the card pattern greatly facilitates the molding. The bronze links cast from the aluminum patterns have the gates cut off and are partially finished and smoothed up before being cast into the chain proper.

22. In order to join the bronze links already cast, special dry-sand molds are employed. Fig. 8 (*a*) shows two bronze links *a* and *b*, which have been placed between the cores of the dry-sand mold. The link *c* is then cast in such a position as to join the separate links *a* and *b*. One of the four cores has been removed so as to show the arrangement of the links, and one of the separate cores is shown at Fig. 8 (*b*). Several links *c* are cast at one time by setting a number of cores in a long box made for the purpose, and having the corresponding number of links in the positions occupied by the links *a* and *b*, Fig. 8 (*a*).

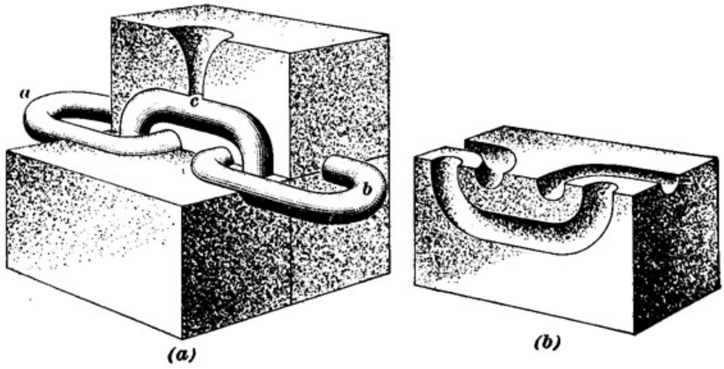

FIG. 8.

23. The core boxes for forming the cores shown in Fig. 8 are illustrated in Fig. 7 (*b*), (*c*), and (*d*). These core boxes should be made of hard wood, or if a great number of castings is required, from metal. When they are made from metal, it is necessary to make patterns for them and to allow the necessary shrinkage on the patterns.

The link portions of the core box are made of aluminum and secured to the wood. It will be seen that the link parts in the box must be accurately located or they will not coincide when the cores are placed together. The ends, sides, and bottom of the box are so arranged that they may easily be removed when the core is rammed up and turned over on the core plate.

The bottom *b*, shown in Fig. 7 (*c*) and (*d*), is secured to the sides by clamps, and the four dowel-pins shown in the sides are for the purpose of locating them each time a core is made. When it is desired to remove the cores from the boxes, the clamps are removed and the bottom taken off carefully, after which the sides are taken away, leaving the core on the core plate.

The gate shown doweled on at *a*, Fig. 7 (*b*), (*c*), and (*d*), is so arranged because it is required in only one-half of the cores, those intended for the lower portion of the molds shown in Fig. 8 (*a*) requiring no gating.

PATTERNS FOR SPUR GEAR AND RACK.

24. Preparation of the Stock for Patterns.—The patterns shown in the views in Fig. 9 are those of a spur gear and rack. The circular pitch is $1\frac{1}{4}$ inches, the face $2\frac{1}{2}$ inches, the rack 25 inches long, and the pinion has 21 teeth, which will give it a pitch diameter of 8.387 inches.

The stock should be carefully selected, first-quality clear pine. The segments of the rim of the gear should be sawed out and the lumber dressed $\frac{1}{16}$ inch thicker than the finished thickness of the segments, after which the pieces should be stacked crosswise and allowed to dry thoroughly. After this, the stock for the hubs and rack is prepared from the same quality of lumber.

25. Rack Pattern.—The plate, or back, *a* for the rack is about 25 inches long, $\frac{7}{8}$ inch thick, and $2\frac{1}{2}$ inches wide, and should be carefully planed straight, parallel, and square with the edges. To make the teeth of the rack,

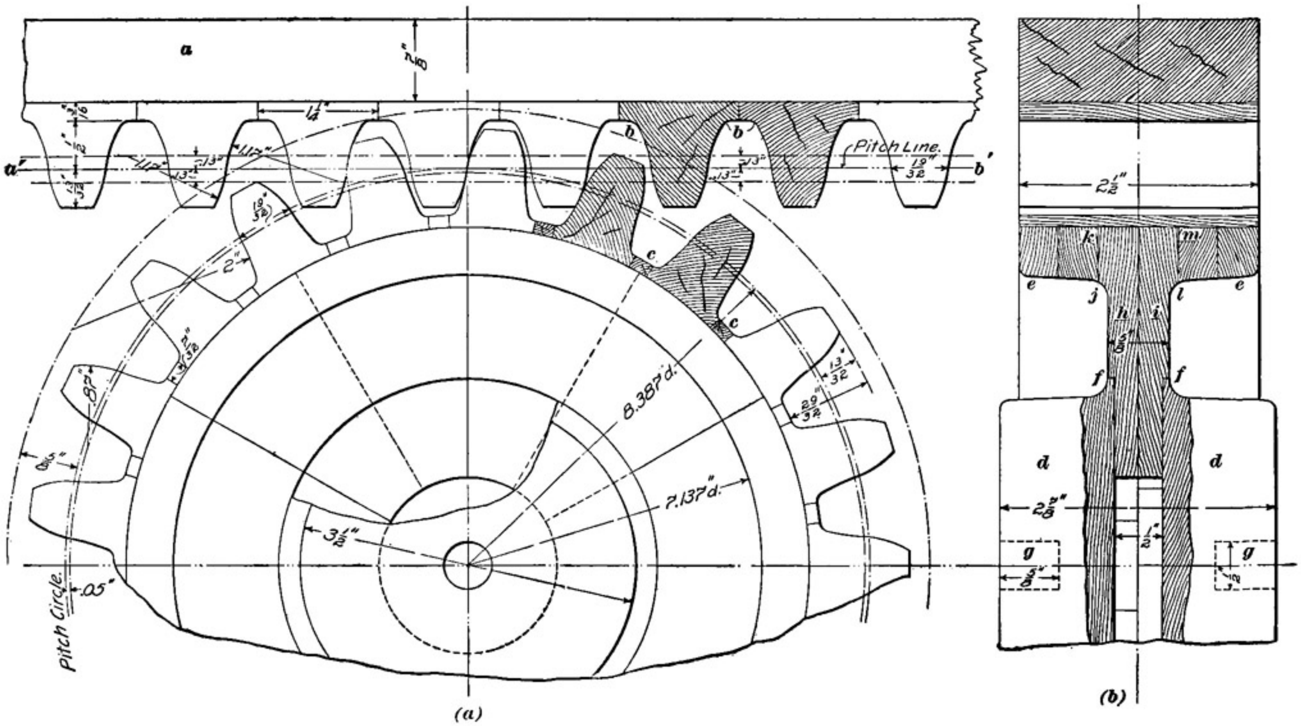
a
b
b
c
c
a'
b'
Pitch Line.
Pitch Circle.
8.387"d.
7.137"d.
3½"
1¼"
2"
.87"
.05"
2½"
2⅞"
⅝"
½"
d
d
e
e
f
f
g
g
h
i
j
k
l
m
(a)
(b)

FIG. 9.

blocks are dressed $1\frac{1}{4}$ in. × $1\frac{3}{32}$ in. × $2\frac{1}{2}$ in. long. The best way to cut out these is to plane up three sticks each 16 inches long, from which the required number of blocks may be cut. To allow for dressing off the ends of the blocks after they are fastened to the plate of the rack, they should be cut about $\frac{1}{8}$ inch longer than the width of the rack. Each of these blocks should be screwed on from the back of the rack with $1\frac{1}{2}$-inch No. 10 screws, no glue being used at first. The teeth are then marked out on the blocks, after which they are removed and cut to the desired shape. Each tooth should be formed, glued, and screwed in place before the next one is removed, making it possible to replace the teeth accurately.

26. Fastening the Teeth on the Gear and Rack Bodies.—The advantage of fastening the teeth of gears in the manner shown, over the old way of dovetailing, is that the fillets *b* at the bases or roots of the teeth can be formed in the blocks from which the teeth are cut, thus making the whole structure stronger. Fillets or round corners at the bases of the teeth are very desirable, as they add strength, rendering the pattern better for molding, and also removing, in a large degree, the effect of cracks at the base of the teeth, due to irregular shrinkage that takes place where sharp angles are left in the casting.

In the rack pattern, it will be seen that there are no pieces fitted between the teeth, as shown at *c* on the pinion. The object of this is to show the different methods that may be adopted for making the gears with fine or coarse pitches. The method employed in the case of the rack is that used for fine pitches, while that employed in the gear is the method suitable for coarse pitches. On account of the fact that the spaces between the large teeth become greater, it becomes necessary to insert a strip between them, as shown, otherwise it would not be easy to work out the teeth from the blocks, which are carried to the center of the space like those in the rack; besides this, the thin parts produced thereby would probably curl up and cause trouble. The strips put between the teeth not only make it convenient to shape them, but act as guides for locating them again after they have been removed for shaping.

27. Building Up the Gear Pattern.—When the rack is completed, and the blocks for the teeth and strips that go between them are prepared for the pinion, the hub should be turned as represented at *d*, Fig. 9 (*b*). After this, the six courses or segments may be built up. A wooden face plate, on which to turn the wheel, is turned about ¼ inch larger in diameter than the inside of the rim of the pinion, and, as both sides of the pattern cannot be turned without chucking, either of the faces *j k* or *l m* may be placed in contact with the face plate. The segments *h* or *i* of the web should be the first to be jointed and laid in place on the face plate. Before doing so, six pieces of paper about 1½ inches wide should be glued on the face plate where the joints of the segments will come. Then the ends of the segments should be glued by putting a little glue on the paper. The first course will then be held to the face plate by these six pieces of paper, and when dried may be faced off true and to the proper thickness in the lathe, ready for the next course.

When one side is built, the inside should be turned and finished to dimensions, as shown at *e*, Fig. 9 (*b*), and the web recessed to fit the edge of the fillet on one of the hubs already turned, as shown at *f*. The outside of the gear should also be roughed off. The pattern is now removed from the face plate, and the edges of the face plate turned to fit the inside *e* of the part just removed. The pattern can be fastened to the face plate with three screws and the other half built up. After this side of the pattern is completed, the inside is turned out and the outside turned to the correct diameter.

28. The blocks that are to form the teeth and the strips that go between them should now be fitted and fastened on, the blocks and the strips being placed alternately around the circumference. The blocks on the rim are secured by screwing them on from the inside with 1-inch No. 8 screws. The strips are fastened in place with glue and fine $\frac{1}{2}$-inch wire brads. All this should be done before taking the pattern from the face plate, because the ends of the blocks must be turned off flush with the rim, and the circles on which the tooth-curve centers are located, marked in the lathe. Before facing off the ends of the blocks, pieces that will just fill the space between the blocks must be fitted and glued between the ends to prevent them from splitting while turning. The grain of the wood in the pieces should run in the same direction as that in the tooth. These pieces will also serve to support the points of the compasses when laying out the curves for the faces of the teeth. When the curves for the teeth are marked out, the filling pieces placed between the teeth should be taken out and the tooth blocks removed and numbered consecutively on the inside, and their places on the rim should be marked with corresponding numbers. The teeth are then worked off, after which they should be glued and screwed back in their respective places.

29. One way of finishing the tooth surfaces to the correct form is as follows: First cut down the blocks until their surfaces are nearly correct. Then make two tooth templets and fix them at opposite ends of a strip *d*, Fig. 10 (*b*), so that the faces *c*, *c* of the curves shall be in line and parallel

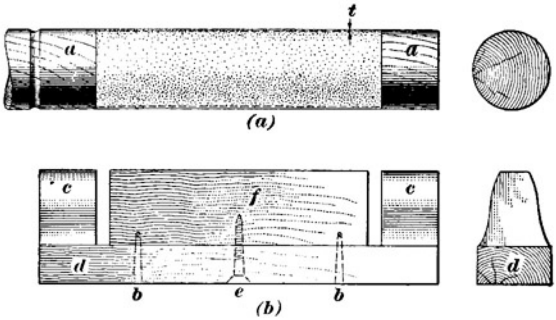

FIG. 10.

with each other. Now turn up a wooden roller, as in Fig. 10 (*a*), having the same length as the strip *d*, Fig. 10 (*b*). At the middle of the roller cut away the stock to a length equal to the distance between the templets *c*, *c* and to a depth *t* equal to the thickness of a sheet of sandpaper. This leaves shoulders at the ends, the length of each of which should be equal to the width of each tooth templet *c*, Fig. 10 (*b*). Glue a piece of fine sandpaper on the roller between the shoulders, and then put the roller into the lathe and rotate it rapidly.

Now take one of the roughly shaped tooth blocks *f*, and by means of a screw *e* and brads *b*, *b*, Fig. 10, fix it firmly to the strip *d* between the templets *c*, *c*. Then place the templet faces *c*, *c* against the shoulders *a*, *a* of the rotating roller, and move the tooth block back and forth. The shoulders will guide the templets, and the sandpaper will cut away the tooth block until it assumes a curve parallel to, and exactly like, the tooth curves on the templets. The other side of the block is treated in the same way without removing it from *d*.

30. Another method of holding the tooth blocks to the rim is shown in Fig. 11. The outside diameter of the rim is made slightly less than would be the case if the teeth were to be dovetailed into it. Then, by means of strips *b*, *b* of trapezoidal section placed between the teeth and nailed to the rim, the blocks are held to their places as by a dovetailed joint. The tooth blocks *a*, *a* can now be numbered and corresponding numbers placed on the rim opposite the blocks.

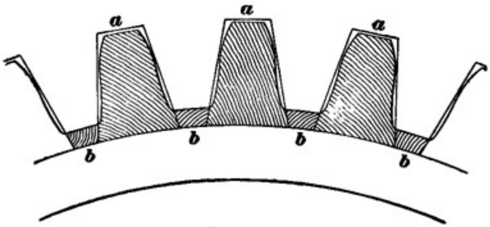

FIG. 11.

The latter may then be driven out, shaped as previously described, and put back again permanently by gluing and screwing in place. This method requires less time and labor than the method of dovetailing each tooth into the rim. It will be seen that the outer faces of the strips *b*, *b* form the bottoms of the tooth spaces; and they must therefore be of uniform thickness.

31. The hubs may also be glued in place after the teeth are completed, but the core prints should be left loose, as the size of the bore is frequently changed, making other core prints necessary. Sometimes the hubs of gears are also left loose for this same reason. This enables one to introduce larger or smaller hubs that will admit of being bored to larger or smaller diameters. In Fig. 9 (*b*), the hubs are shown in place and the dotted lines at *g* indicate the position of the holes for receiving the pins for the core prints, but the core prints are not shown in place.

MITER AND BEVEL GEAR PATTERNS.

32. General Consideration.—To cast a pair of miter gears (gears making an angle of 45°) that will mesh and run together, only one pattern is required, while, in order to cast a pair of any other bevel gears, two patterns are necessary, because the angle in each is not the same on the face and they each contain a different number of teeth.

When looking for a certain gear pattern among others, an experienced patternmaker can generally distinguish the difference between a miter and any other bevel gear without trying the angle, but where there is only a small difference, it is not easy to distinguish between them without testing their angles or referring to the records. For this reason, it is well to stamp the word *miter* or *45°* on all miter-gear patterns. The method of constructing a pattern for either miter or bevel gears is the same, and only one example need be considered.

33. Pattern for Bevel Gear. — The method of making the gear pattern shown in Fig. 12 (*a*) and (*b*) is not a general one, differing from common practice in the way in which the teeth are fastened. The teeth are usually

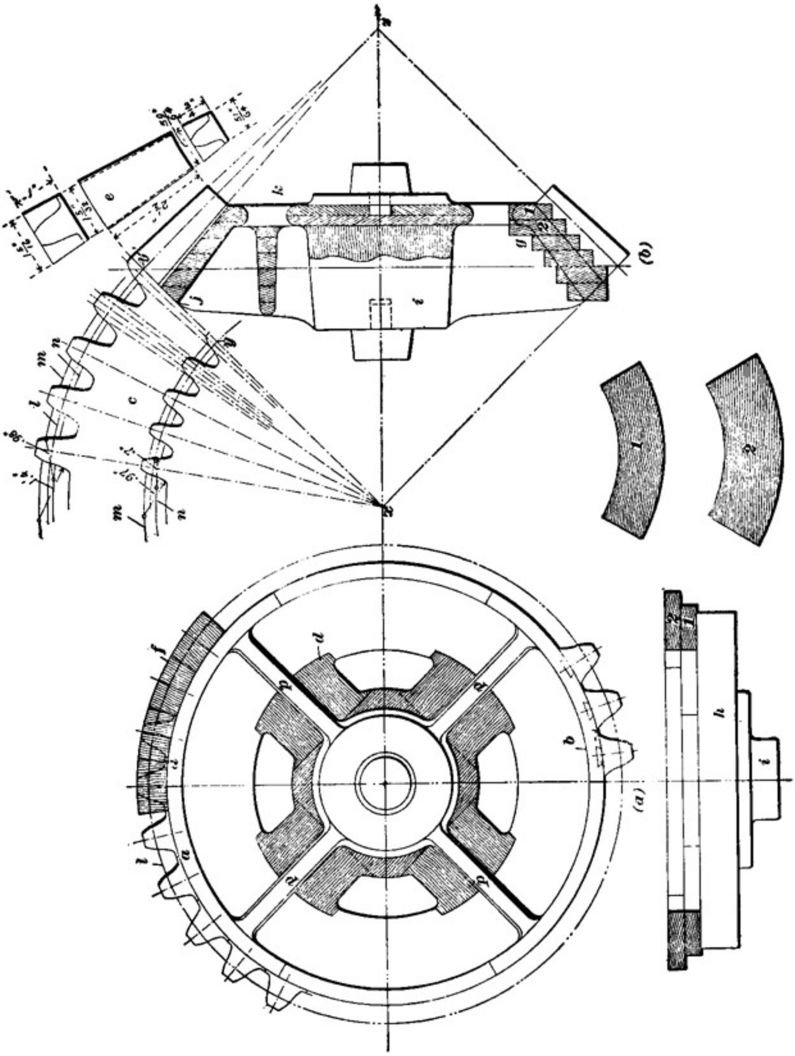

FIG. 12.

dovetailed into the rim, as shown at *b*, Fig. 12 (*a*), the dovetail being made with a slight taper so that the teeth can readily be driven out and replaced. Another method sometimes employed consists of gluing the blocks for the teeth on the rim without dovetailing them and then shaping them while in place. The rim of the wheel in both instances is turned to the correct diameter at the root of the teeth. In the method shown at *a*, Fig. 12 (*a*), it will be seen that the rim is turned under the size and then the blocks for the teeth are formed so as to make up the difference.

The first of these three methods has many points to commend it, as it allows the blocks to be removed for dressing the teeth separately. It does not, however, permit the fillet to be worked out at the bottom of the tooth. The second method is not good, because if the fillet is made at the root of the tooth, the feather edge thus formed is liable to curl up. Another bad feature of this second method is that all the teeth must be dressed off in place, which is not so easy to do as when the blocks are removed or when every second one is removed. The method shown at *a* has the advantage of having a fillet at the root of the tooth without the feather edge, and of permitting every second block to be removed for the purpose of shaping the teeth. It will also be seen that all the joints of the segments forming the ring are covered between the teeth, which is a desirable feature.

34. To make a bevel-gear pattern, a full-sized section of the rim must first be drawn, as shown at *g*, Fig. 12 (*b*), in order to lay out the width, thickness, and diameter of the courses of segments. In the pattern illustrated, six segments are used.

The profiles of the outer and inner ends of the teeth that are shown at *c* are drawn in the same way as the teeth for two spur gears whose radii are xy and xy', with pitches corresponding to the inner and outer ends of the tooth. It is seldom that the two circles y and y' can be spaced without a remainder, but this fact is of no account, as they are only auxiliary circles that are used for convenience in laying out. In building up the rim, a wooden face plate *h*, Fig. 12 (*c*) is employed. This is screwed to an iron face plate *i* and the segments are glued to the wooden face plate, the course marked *1* being glued on first with a piece of paper under each joint.

The course of segments *2* is next glued on course *1* and faced off, and the succeeding ones added until all are in place. The rim is then turned inside and roughed off on the outside. Before removing the pattern from the face plate, the four arms should be let in and glued to the rim, as shown at *d*, Fig. 12 (*a*), the arms having been previously half checked together and formed to the required shape. The hub is turned on a screw chuck and left a little larger than the required size. It is then glued to the arms, and when the glue is thoroughly dry, the arms are faced off and the hub finished so that it will run exactly concentric with the rim, thus enabling the patternmaker to chuck the pattern by means of the hub. The wooden face plate *h*, Fig. 12 (*c*), used in turning up the outside and inside of the pattern, is made smaller than the diameter of the gear at the small end, so as to allow the outside of the gear to be roughed off during the first operation.

35. After the pattern is removed from the face plate, a larger wooden face plate is provided, having a piece at the center so as to allow a greater thickness of stock to receive the hub. The center part of the face plate is turned to receive the hub *i*, Fig. 12 (*b*), and the corner of the pattern *j* is allowed to rest against the face plate so as to act as a support and prevent the pattern from trembling while turning the outside of the teeth. After the pattern is chucked, the face *k* and the outside are turned to the required dimensions, ready to receive the teeth. The hub and the core print may also be added and turned.

36. Fastening and Forming the Teeth.—In getting out the blocks for the teeth, they should be made about

$\frac{1}{16}$ inch longer than those shown at *e*, in order that the ends may be turned off. The rim having been turned, it is spaced off on the face for the teeth, the lines being drawn toward *z* by the use of a center square. The blocks for the teeth are fitted on the rim, as shown at *f*, Fig. 12 (*a*). All the blocks are glued together above the root of the finished tooth, on the sides, near the outer ends, but only every alternate one is glued to the rim. They are thus secured for turning. Particular care must be taken when gluing, to prevent any glue from getting on the sides of the blocks near the rim, as at *a*, Fig. 12 (*a*), or below the bottom of the finished tooth, and only freshly made, thin glue should be used.

When the glue is thoroughly dry, the ends and faces of the blocks may be turned. To make a good surface for marking the teeth, a light coat of yellow varnish should be given to the blocks and when dry they should be sandpapered. The pitch circle *l* and the circles *m* and *n* for the centers of the arcs forming the tooth curves are drawn on both ends of the gear, after which the profiles of the teeth are laid off on the inside and outside.

After this laying out is done, the joints of the blocks are sawed down all around to the bottom of the glue, relieving them and allowing every alternate one to be removed, thus rendering the paring of the teeth much easier than if all were glued on the rim. When removing the blocks for paring, they should be numbered so that they can be properly replaced. After all the teeth are completed, those that have been removed are replaced and glued to the rim. The fillets at the bottoms of the teeth are formed from the blocks from which the teeth are formed. In the case of gears of large pitch, it may be necessary to introduce strips of wood between the teeth, as in the case of the gear illustrated in Fig. 9. The ribs *p* are fitted in place after the turning is complete, because, if they were introduced before the chucking, they would interfere with the chuck.

WORM AND WORM-GEAR PATTERNS.

WORM-PATTERN.

37. Preparation of the Stock.—If it is required to make a pattern for a worm 4 inches in diameter with a single right-hand thread having $1\frac{3}{4}$ inches pitch, the following course may be pursued. First, turn the pattern, which should be in halves, to the required diameter and length, as shown in Fig. 13 (*a*). The core prints *a* and *b* may be turned on the pattern, as shown, or they may be turned afterwards and attached to the pattern. When turning

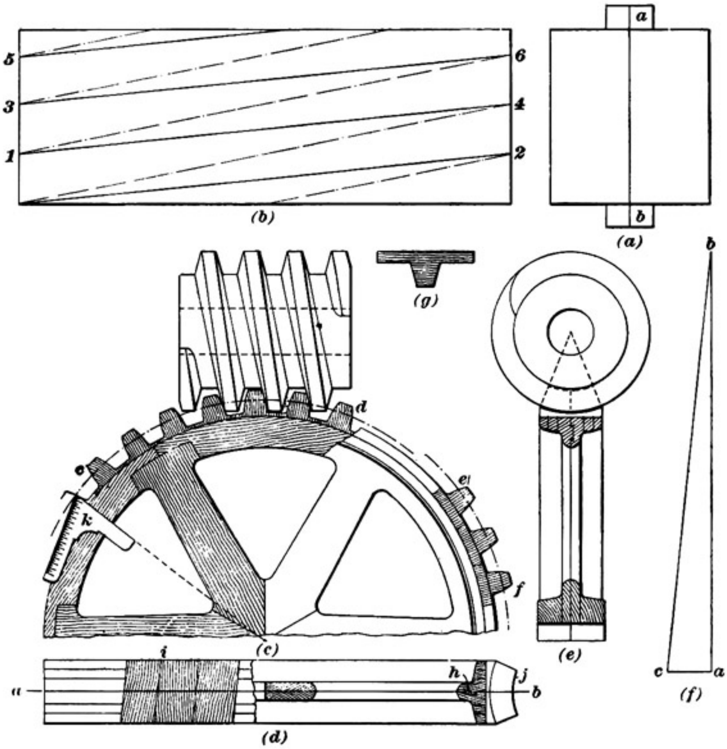

FIG. 13.

such a pattern as this, it is best to have metallic plates attached to the ends and to use conical centers. This will enable the work to be returned to the lathe after the threads are cut, so that the threads may be sandpapered while the lathe is revolving at a slow speed. A much better job of sandpapering than could otherwise be done is thus insured.

38. Laying Out the Thread.—After turning the pattern, a piece of paper should be wrapped around it and cut to the exact length of the circumference and also the length of the pattern. The paper should then be laid off as shown in Fig. 13 (*b*). The points *1*, *3*, *5* and *2*, *4*, *6* are laid off on the edges of the paper $1\frac{3}{4}$ inches apart and the full lines drawn connecting them, as shown. These lines represent the center line of the thread. After the lines are drawn, the paper is wrapped around the pattern again, when it will be found that point *1* will meet point *2*, point *3* will meet point *4*, and point *5* will meet point *6*, thus making one continuous line when wrapped on the pattern. The paper is finally glued on the pattern, but before this is done, other lines should be drawn parallel to these, representing the thickness of the thread or the lines on which it is desired to saw down for the sides of the thread.

39. In laying out the lines, care must be taken not to run the thread in the wrong direction, making a right-hand instead of a left-hand or a left-hand instead of a right-hand thread. This mistake is very easily made. If the thread is to be a right-hand one, the lines should run up toward the right hand, as seen in Fig. 13 (*b*), and if it is to be a left-hand thread, they should run up toward the left.

When a double thread is required, instead of starting to draw the lines from point *2* to the corner, point *1* to point *4*, point *3* to point *6*, etc., they should be drawn as indicated by the broken lines, so that each line advances two divisions instead of one. By following out this system, any number of threads can be drawn. If the lines advance three points, a triple thread would be formed; if they advance four points, a quadruple thread, and so on, until the number of threads and the angle are so great that it is called a spiral gear in place of a worm.

40. If the entire surface of the paper were covered with glue, the moisture of the glue would stretch it so that the ends, instead of meeting, would overlap. This can be avoided by simply placing a little glue along the ends and a spot here and there on the inside of the paper, and not covering the entire surface with glue. After this is done, the paper should be laid down and the pattern rolled over it, when the paper will adhere to the pattern and take its proper position.

41. Forming the Thread.—The cutting of the thread may be done with a back saw, but before beginning the work, two pieces of hard wood about $\frac{1}{4}$ inch thick should be fastened to the sides of the saw to act as guides and to prevent the saw from cutting beyond the desired depth. With the saw thus prepared, two spiral lines may be sawed about the worm and the space between removed with a chisel, after which the form of the thread can be finished out to a templet, shown in Fig. 13 (*g*). The form and angle of this templet will depend on the kind of thread to be cut.

Some patternmakers have two small holes drilled through their back saw to enable them to fasten wooden guides on it, while others allow the guides to project beyond the ends of the saw to secure them together by means of screws. After the thread has been formed to the desired shape, the pattern may again be placed in the lathe and sandpapered.

A worm, especially if it is long, may be roughed out on a circular saw. The worm is turned to the desired outside diameter, the spiral laid out on it, and one or two turns worked out $\frac{3}{16}$ or $\frac{1}{4}$ inch deep at one end, so as to form a guide. A wooden box or guide is so placed on the saw table that when the worm rests against the guide the saw will enter the groove parallel to the thread of the worm. A small pin one turn in advance of the saw blade engages the groove that has been worked out by hand. The operator rotates the worm against the guide by hand, and the small pin feeds it along the guide. The saw cuts a groove that is a continuation of the groove worked out by hand, and after the guide pin has passed the portion worked out by hand, it engages the portion cut by the saw, and the work becomes continuous. A groove from $\frac{3}{16}$ inch to $\frac{1}{4}$ inch deep is sawed down on each side of the thread the entire length of the worm. The saw is then moved over and the table lowered slightly so that another cut can be taken next to the one previously made. The guide pin must be readjusted each time so that the saw will rough out the stock almost to the face of the thread. By repeating this operation, practically all the material in the groove can be sawed out in a very short time.

PATTERN FOR WORM-GEAR.

42. Requirements and Form of Tooth.—If a worm-gear is to mesh with the worm described in Arts. **37** to **41**, the wheel being $21\frac{3}{4}$ inches in diameter, $1\frac{3}{4}$ inches pitch, and having 39 involute teeth, the work may be done as here described. Involute teeth may be laid out by the Willis odontograph, as described further on. Many patternmakers shape the thread of a worm the same as that of the tooth of the gear in which it is to work, but in this case the sides of the thread have the form of involute teeth and should be straight and at an angle of 75° with the axis of the worm. This is the correct form for the involute rack tooth, and the worm is similar to the rack in this case.

43. Building Up the Body of the Pattern.—A section of a worm-gear pattern is shown in Fig. 13 (*d*), the pattern being parted on the line *a b*. In turning the pattern, the face plate should be the same diameter as the rim so as to allow the ends of the teeth to be turned off. Each half of the pattern should be built up separately with the parting joint of the pattern against the face plate. The outside of both halves of the pattern should be roughed off and the inside faces of the arms finished carefully, care being taken to turn the inside of both halves to the same diameter so as to make the chucking easier. When this is done, the rings are chucked by the inside of the rim so that the parting face of the pattern is on the outside. If the arms have already been placed in the pattern, this chucking may be accomplished by means of segments nailed or glued to the face plate, and so placed that they will fit between the arms. The outside of these segments is then turned so that the pattern will just fit over them. The outside of the rim should then be finished to the required size and blocks for the teeth fitted upon the periphery.

44. Fastening and Facing the Teeth.—The blocks for the teeth should be fitted and glued on with the grain of the wood running at the same angle as the teeth at the pitch line, the width of each block being equal to the pitch. The angle of the teeth is laid out as shown in Fig. 13 (*f*), in which *a b* represents the circumference of the worm on the pitch line and *a c* the pitch, while the angle *a b c* represents the angle of the teeth at the pitch line. The three blocks at *i*, Fig. 13 (*d*), are shown fastened on at the proper angle. These blocks are fastened on before taking the first half of the pattern from the lathe, and they should be faced off true with the parting line of the pattern. The groove shown at *h*, Fig. 13 (*d*), may also be turned at this time.

After the first half of the pattern has been turned and removed, the second half is chucked and turned and the blocks for the teeth fitted on, care being taken to place the blocks so that they will come in line with those on the first half when the arms of the pattern are in their proper position. A projection should also be turned on this half of the pattern to fit the groove *h*, Fig. 13 (*d*), and this groove and projection will serve to locate the halves of the pattern concentric with each other when they are brought together.

The halves should now be put together before the second half is removed from the lathe, the second half being secured to the first half by means of screws or clamps. The blocks for the teeth should be turned off on the ends and finished to the proper form, as shown at *j*, Fig. 13 (*d*). To provide a good surface for laying out the teeth, the blocks should be varnished yellow and sandpapered.

45. Laying Out and Forming the Teeth.—In Fig. 13 (*c*) a series of teeth is shown from *c* to *d* with one-half of the gear pattern removed so that the section of the teeth on the center line and their contact with the worm may be more clearly illustrated. The projection of the portion of the teeth that extends beyond the center line is not drawn in. In the portion of the figure from *e* to *f*, three teeth are shown, illustrating an end view of them. Owing to the fact that the teeth on the outside edge of the worm-wheel have a greater pitch diameter than those in the throat, they will have a greater chord pitch, and hence if the teeth are formed of the same cross-section clear across the face of the worm-wheel, the worm will not fit them perfectly. The longer the portion of the worm that engages the worm-wheel, the greater the error that can be produced from this cause. To remedy this, the outer ends of the teeth should be cut thinner than the theoretical thickness. In order to determine the amount to be pared off from the outer ends of the teeth, it should first be determined how many of the teeth of the worm-wheel are in contact with the worm at one time, and a pair of dividers should be set to this contact distance. This distance can then be compared with the thickness of the teeth at the outside edge, when it will be found that the dividers are set to a considerably smaller dimension than the over-all dimension of the corresponding number of teeth. One-half of the difference between the divider setting and the over-all distance of the teeth at the outside of the worm-wheel should be pared off from each side of the teeth at the outer edge, and this amount should taper to nothing at the center. In laying out the amount to be removed, measurements may be taken at two or three points along the teeth. This error is much more noticeable in worms having a long contact.

46. In the form of teeth shown, the tooth curves may be struck in with the compasses, provided the proper center has been ascertained. This is done by means of the odontograph, which is shown at *k*, Fig. 13 (*c*). The odontograph is shown more plainly at *a*, Fig. 14. The instrument consists of a 75° angle divided off into $\frac{1}{4}$-inch spaces on one side for 4 inches in length, the $\frac{1}{4}$-inch spaces being subdivided. When in use, the zero point of the instrument is placed at a point on the pitch line that corresponds with an intersection

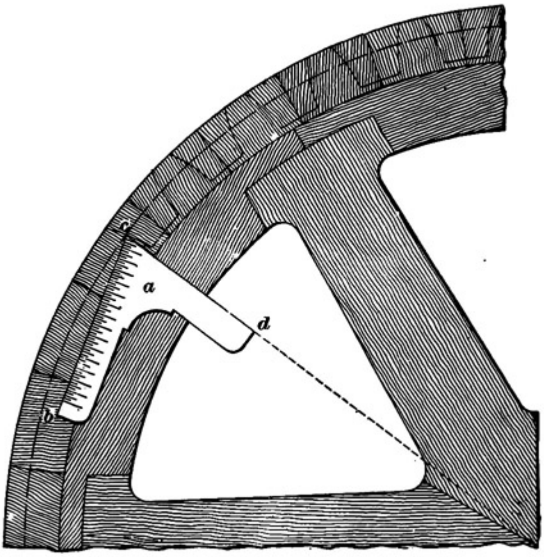

FIG. 14.

of the face of one of the teeth with the pitch line, and the plain side *c d* of the instrument is placed on a radial line, as indicated in Fig. 14. A distance corresponding to the radius of the gear is then read off on the graduated side of the instrument, the $\frac{1}{4}$-inch spaces being read as inches. This will locate a point from which the tooth curve can be struck. In the case of the wheel under consideration, the diameter is $21\frac{3}{4}$ inches and the radius $10\frac{7}{8}$ inches. This is so near

11 inches that, for practical purposes, 11 inches could be read off on the odontograph and the point placed for the center of the tooth curve. This method is continued around the entire gear. The diameters of the circles containing the centers of the circles forming the tooth curves are usually furnished by the drawing room and placed on the drawing. When this is not done, the odontograph may be used.

47. To insure the proper angle on the face of the tooth, the center of one of the blocks on each side may be located on the pitch line and the spacing on the two sides continued from this. If the blocks have been placed at the proper angle, this will insure the teeth being at the proper angle. It is also well to take the pattern apart and lay off the tooth curves at the center on one-half of the gear. This half is then trimmed to the proper form and placed in contact with the other half, after which the remaining portion of the teeth can be shaped.

48. Strengthening the Pattern Arms.—Since the arms of the pattern are made in halves, they are thin, and therefore weak. In order to give them the greatest possible amount of strength, the joints at the center should be tongued and the hub on each side glued and screwed to the arms, which will, in most cases, give the requisite amount of strength. Only one dowel-pin will be necessary to insure the halves of the pattern going into their correct positions, as the annular groove and tongue shown at *h*, Fig. 13 (*d*), will center them, and all that is necessary is to bring the teeth into the correct relationship on both halves.

FLYWHEELS WITH HOLLOW ARMS.

49. Advantages of the Different Designs of Flywheels.—Many persons contend that flywheels whose rims are made in eight or ten sections would be just as strong if cast in halves. When the rim is made in a number of sections, the arms and hub are made separate and the parts bolted together; while, when the wheel is cast in halves, the arms and rim are usually cast together. It is certainly cheaper to cast wheels in halves than in a large number of segments. The matter of first cost, however, should always be made secondary to that of durability and strength, on account of the fact that a bursting flywheel is liable to cause great damage.

50. The method of making the wheel in sections possesses certain advantages, among which may be named the fact that it is more easily handled in the shop and is not subject to as great strain from shrinkage as one made in

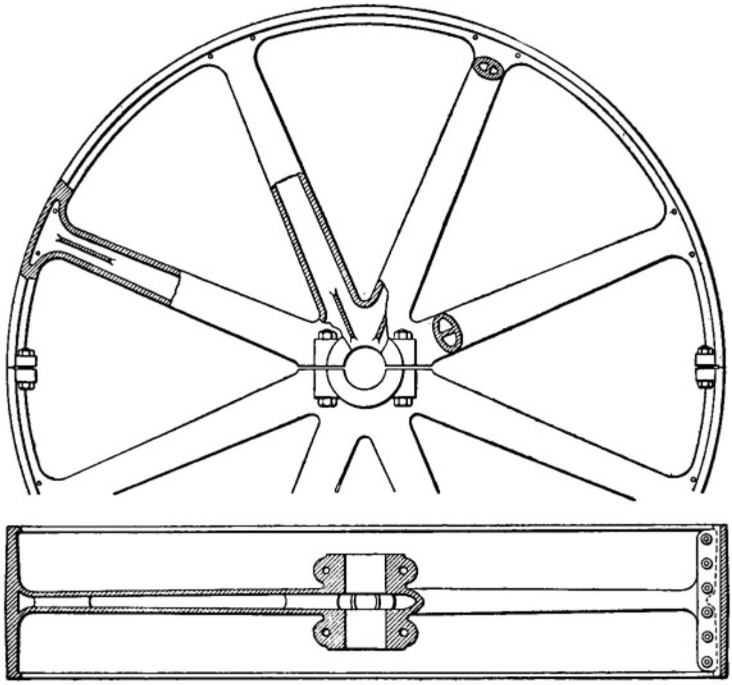

FIG. 15.

halves. On the other hand, when the wheel is made in sections, there is danger of the loosening of the bolts and joints, and a wheel built in sections is generally more difficult to balance than one cast in halves. Flywheels with solid arms are often cast in halves, especially when of comparatively small diameter. The flywheel described in the following articles and illustrated in Fig. 15 is 20 feet in diameter, with a 50-inch face, and weighs about 22 tons. It was successfully cast in the kind of mold described and has been running for several years. Ordinarily, such a large wheel would have been cast in sections.

51. Strength of Arms.—The necessity of making a flywheel strong enough to withstand the shrinkage strains of cast iron while cooling is sometimes overlooked. The cross-section at the small part of the arm may be made large enough to withstand all working strains, but not strong enough to withstand the strains due to cooling. For this reason, most flywheels that give out crack while cooling in the foundry. This cracking is usually due to an insufficient amount of metal in the arms compared with the other parts, thus causing the arms to cool too quickly. The molder often prevents this by uncovering the heavy parts of the casting first, especially the hub, thus allowing the whole casting to cool simultaneously, or nearly so. The shrinkage strains, however, may be so great, owing to ill proportioning, that, with all the precautions a molder can take, the wheel will break, and hence the draftsman should always consider the shrinkage strains when designing the flywheel arms, and the patternmaker should have sufficient knowledge of molding so that he will be able to judge as to the results that will occur when making any given casting and will also be able to help the draftsman in correcting any faulty designs.

52. General Consideration of Flywheel Mold. The flywheel shown in Fig. 15 may be molded as shown in Fig. 16, the greater part of the mold being composed of dry sand cores. The portion of the mold for the arms is formed by the outside cores shown at *a*, Fig. 16 (*a*) and (*b*). The cores to form the inside of the arms are shown at *b*. The space *c* between the cores *a* and the rim of the wheel *d* is filled with green sand, which is rammed against a part pattern, as shown. The outside of the mold is composed of curved cores *e*, Fig. 16 (*b*); the portion of the mold for the hub is formed by the cores *f* and *g*, while the opening through the hub is made by the cores *h* and *i*.

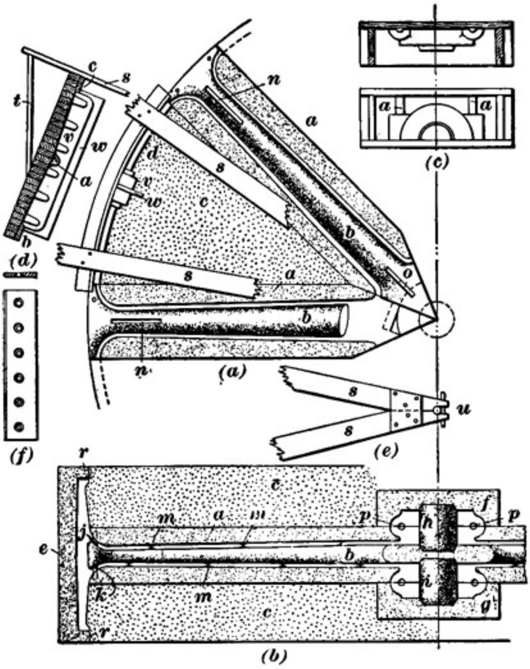

FIG. 16.

53. Appliances for Making Cores for the Outside of the Arms.

—A core box for the outside of the arms is shown in Fig. 17 (*a*) and is fitted with interchangeable pieces *a* in the end of the box. These interchangeable pieces are for forming the hub, or rather for forming the space for the hub cores. In Fig. 17 (*b*) is shown a plan of the hub cores, and three sections must be made to correspond with those numbered *1*, *2*, and *3*. These three sections are used at *a*, Fig. 17 (*a*), in forming the arm cores. By referring to Fig. 16 (*b*), it will be seen that the cores *b* are supported at their outer end on the cores *j* and *k*, and also by chaplets *m*. In order to provide for the cores *j* and *k*, the core box shown in Fig. 17 (*a*) must be provided with core prints *b*. These are also shown in the partial sections of the core box, Fig. 17 (*c*) and (*d*).

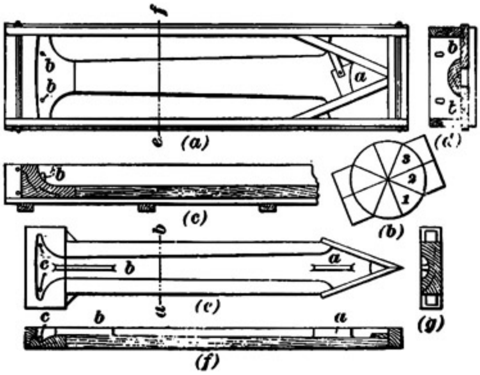

FIG. 17.

54. Core Box for Inside Arm Cores.—A core box for making the cores *b*, Fig. 16 (*a*) and (*b*), is shown in the three views, Fig. 17 (*e*), (*f*), and (*g*). It will be noticed that the pieces *a* and *b* are fastened into these core boxes to form openings for the stays or webs *o* and *n*, Fig. 16 (*a*); core prints *c* are provided to receive the ends of the cores *j* and *k*, Fig. 16 (*b*). In the case of the cores for both the inside and the outside of the arms, only half core boxes are necessary.

55. Core Box for the Outside of the Rim.—The core box for making the core *c*, Fig. 16 (*b*), for the outside of the rim is shown in Fig. 18. The box is very simple in construction, being composed of a simple rectangular box having perpendicular ends *a* and *b* and inclined sides *c* and *d*. The face *e* of the box is open, so that the core can be readily removed in this direction. The upper faces of the ends *a* and *b* are shaped to the same curve as the ends of the core *c*, Fig. 16 (*b*). There are also two ribs *f* and *g*, which are placed across the box at a sufficient distance apart to form the inside of the core. It will be noticed by reference to Fig. 16 (*b*) that the cores are longer than the width of the rim, and the distance from outside to outside on the ribs *f* and *g* is equal to the width of the rim, a proper allowance for shrinkage having been made. Instead of making the entire upper surface of the core box and ramming the core between it and the back plate on the ribs *f* and *g*, the sand between them is swept out by means of the strickle *h*, which runs on the ribs *f* and *g*. The core is all rammed from the upper or inner face, the central portion swept out with a strickle, and the core box then lifted off, thus leaving the finished core on the core plate ready for drying.

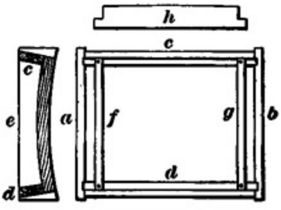

FIG. 18.

56. Core Boxes for the Hub.—The cores *i* and *h*, Fig. 16 (*b*), are made in ordinary circular core boxes or swept up on iron arbors, and hence no description of the core boxes need be given. The cores *f* and *g* are made in halves in the box shown in two views in Fig. 16 (*c*). The cores for making the bolt holes *p*, Fig. 16 (*b*), are supported in the recesses left by the core prints *a*, Fig. 16 (*c*). These bolt cores are made larger in the center so as to chamber out a portion of the hole and thus reduce the work necessary in drilling and reaming the holes and fitting the bolts. Making the cores *f* and *g* in halves greatly facilitates the placing of the cores for the bolts *p*, Fig. 16 (*b*).

57. Green-Sand Work in Connection With the Mold.—The mass of green sand between the rim and cores *a* is rammed against the part pattern shown in place at *d*, Fig. 16 (*a*), and also shown in section at Fig. 16 (*d*).

The inside rib *a* is not built up with the segment or part pattern, but is separate and screwed on after working off the inside of the segment, this being a much easier way than building the rib in the pattern. The two ribs *b* and *c* are also made separate and screwed on the segment after the body is completed.

The segmental pattern is made wider than the face of the wheel required, in order to make allowance for the ends of the core, as shown at *r*, Fig. 16 (*b*). The segmental pattern is held in place by two wooden arms *s*, Fig. 16 (*a*), and the lower portion of it is braced by suitable braces *t*, Fig. 16 (*d*). At the center of the mold the arms *s* are attached to a center pin *u*, as shown in detail, Fig. 16 (*e*).

The segmental pattern is represented with the lug *v* for bolting the wheel together on it. This lug is removed when ramming up the space between any two arms whose centers do not come on the joint line of the wheel. After the green-sand portions *c* have all been rammed up, the cores *e*, Fig. 16 (*b*), are placed in position. The mold, if above the floor of the foundry, is surrounded with a ring of boiler iron, and green sand is rammed in back of the cores *e*. In some cases, the mold is built in the foundry floor and sand is simply rammed back of the cores *e* so as to fill the remainder of the pit. This wheel could also be made by building up the outside portion with brickwork and sweeping loam on it, instead of using the cores *e*, Fig. 16 (*b*). As the wheel is to be turned on the outside, it is not important that it should be smooth, and the method here illustrated is in many cases cheaper and more convenient.

58. In order to form a joint for the wheel, cast-iron plates, similar to those shown in Fig. 16 (*f*), are introduced into the joint to fill the space left by the core print *w* on the segmental pattern. These plates have a series of holes in them through which the cores for the bolt holes are to be placed. The holes in the plates should be ½ inch or so larger than the cores for the bolt holes, so that some metal may flow through the holes and around the cores, thus giving an abutting surface surrounding each bolt. The hub of the wheel is also split by means of cast-iron plates, but no allowance is made in the case of the holes in these plates to have an abutting surface of metal about the cores for the bolts. All the venting from the cores in this mold is taken care of through the center cores *h* and *i*.

The patterns, core boxes, and molds for wheels with solid arms may be made as just described, except that the cores in the arms are omitted. Solid arms are now generally used.

PATTERNMAKING.

(PART 5.)

PATTERNS FOR SCREW PROPELLERS.

1. Development of the Curve for the Blades. In order to lay out the curve representing the pitch of a **propeller screw,** the following method may be used. If a cylinder were drawn with a diameter as shown in Fig. 1 (*a*), the diameter being equal to the distance across the points of the blades of the propeller and the line *a b* equal to the pitch of the screw, then the curved line joining these two points would represent the course of the blades if they were continuous. In order to determine the angle that these blades make, lay off *b c*, equal to the circumference of the cylinder, perpendicular to *a b*, and join the points *a* and *c*. The line *a c* will represent the length of the screw between *a* and *b*, and the angle at *e* will represent the angle that it makes at any point on the surface of the cylinder. If a piece of paper of the form *a b c* were cut out and wound around the cylinder, it would form the helix shown, and the point *c* would come around to the point *b*. If it were desired to continue this helix about the cylinder, other lines parallel to the line *a c* could be drawn as represented by the dotted line *y*, and if this were wound around the cylinder, it would form a continuation of the helix, the point *d* coming to the point *a*, etc., thus making a continuous thread. This method is the same as that used in laying out the threads on worms. The curved line representing the thread about the cylinder shown in Fig. 1 (*a*) is of no use in laying out the drawing,

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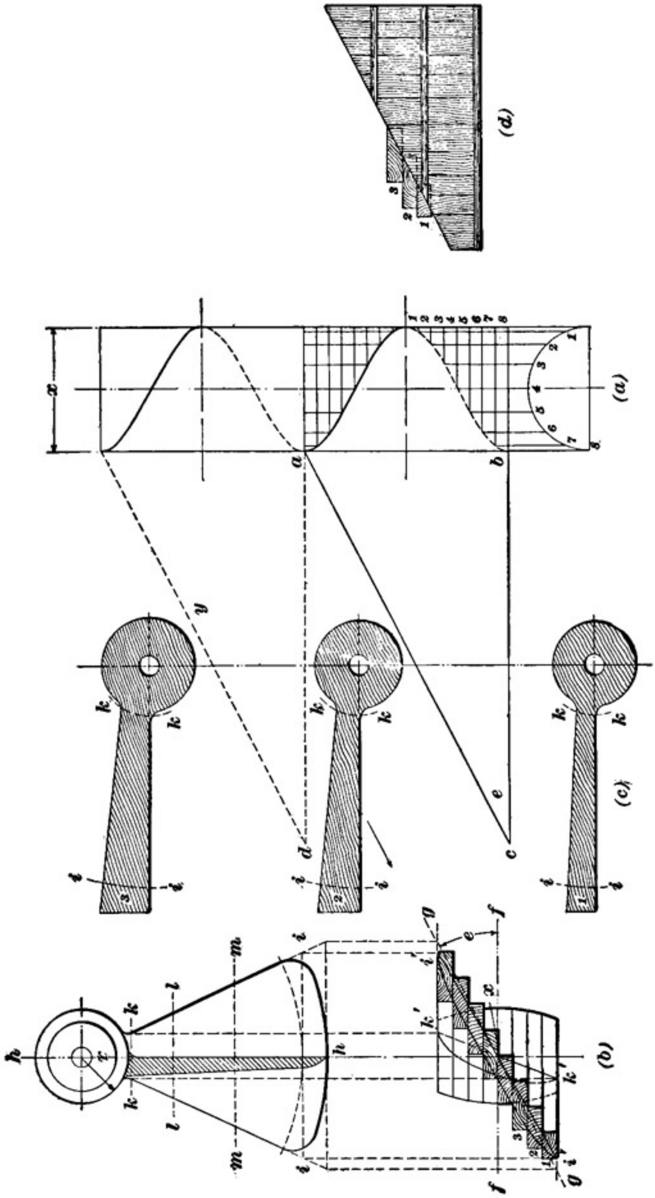


FIG. 1.

but has simply been projected for the purpose of illustration, the projected points being numbered the same in the half plan of the cylinder and in the elevation, so that the method of projecting may easily be understood. The angle *e* that the outer end of the blade makes with the direction of its center line is the important point in the laying out of a screw propeller wheel.

2. Styles of Propeller Patterns.—Usually, a whole pattern is made for a small propeller wheel having three or four blades, as such a pattern saves much time in the molding, but when the pattern is 5 or 6 feet in diameter or is not liable to be used often, the molder can make a pattern for one blade answer the purpose for three or four by moving it around the spindle and ramming up the cope and drag in sections. The principles here given for building up one blade will also apply to a pattern having three or four blades.

3. Laying Out the Blade.—Fig. 1 (*b*) shows one manner of laying out a propeller blade when there is no rake aft. Having obtained the angle of pitch *e*, Fig. 1 (*a*), it is an easy matter to transfer it to the blade. To accomplish this, draw the line *f f* across the center of the hub, and draw the line *g g* at an angle *e* with *f f*, the intersection being at the point *x* upon the vertical center line of the hub. Where the lines *f f* and *g g* intersect at *x* is the center of the blade represented by the line *h h* in the plan, and through this line the face must pass.

Having located the lines *h h* and *f f* and the angle *e* on the hub, the outline and longitudinal section of the blade are laid out, the longitudinal section of the blade being shown cross-sectioned in the upper view and the outline of the end being shown in full lines intersecting the line *g g*. It will be noticed that the outline does not exactly coincide with the line *g g*. This is so because the ends *i i* recede from the line *g g* in order to conform to the surface of the cylinder, and hence appear above and below the line *g g*.

The section on the line *h h* shows the actual thickness of the center of the blade lengthwise, while the outline on the line *i i* does not show the actual thickness, because it is projected. The shape of the outline of the blade is drawn on the pattern after it is built up. Different designers hold various opinions as to the best outline for a propeller, and the one chosen has simply been adopted for the sake of illustration.

To get the cross-section of the blade at the hub, the angle that the blade makes at the hub must be determined. This is done by drawing the lines from *k k* in the upper view until they cut the same upper or lower lines that *g g* do in the lower view, as shown at *k' k'*. Then *k' k'* will be the angle, but the intersection of the blade at *k k*, falling as it does on the round surface of the hub, will not appear straight as shown. It is drawn so in order to simplify the drawing, and, as it is intended for the patternmaker's working drawing, will answer all practical purposes. The cross-sections at *l l* and *m m* are omitted, but they may be obtained by projecting lines from the points at which these intersect the lines bounding the sides of the blade on to the lower view, and drawing diagonal lines similar to *k' k'*, on which the sections may be drawn.

4. Building a Propeller Pattern.—Having obtained all the lines needed, the material for the pattern may be gotten out. Care must be taken to see that each course is parallel, for, if it is not, the building up will give trouble and cause the pitch to vary from that desired. In the lower view, Fig. 1 (*b*), it will be noted that the patternmaker is guided, in forming the straight face of the blade, entirely by the positions of the corners of the segments as they are laid up, these segments being brought into contact with the line *i' i'*. For the sake of illustration, the material is cut as close to the line on the back of the blade as it is on the face, but there ought to be more stock allowed on the back than is represented in the drawing. In Fig. 1 (*c*) are illustrated the first three courses of the pattern numbered *1*, *2*, and *3*. The width of each course is determined by the end view, Fig. 1 (*b*), and the width at *k k* is obtained by drawing a circle on each course with a radius equal to *r* in the plan in Fig. 1 (*b*), and then transferring the different widths as seen at the section *k' k'* in the end view and adding enough stock to form the fillet at the hub.

In cutting out the courses, the grain of the wood should run as indicated by the arrow shown opposite segment *2*, Fig. 1 (*c*), as this will make the cutting and shaping of the blade much easier than if the material were sawed out with the grain running straight.

A wooden pin should be turned the same diameter as the spindle on which the pattern is to be used, and a hole bored in each segment to fit this pin. The courses of the blade are then slipped over the pin in their proper order, thus keeping all the courses parallel to one another, and at the same time permitting them to be swung to their proper positions.

Although each course may be of even thickness and the correct bevel laid off on the end of each piece, there is danger in the building up of the courses that they may lean over too much. To prevent this, it is a good plan to make an angle piece as shown in Fig. 1 (*d*). This angle piece is laid off with the same angle as that shown at *e*, Fig. 1 (*a*), and is used for a guide and support while building up the blade. The angle piece is built in the form of a cylinder, having a circumference equal to that of the periphery. Each course for the periphery of the blade is beveled off for a short distance in from the end so as to rest on the incline of the angle piece, care being taken not to destroy the upper radial edge of each course in doing so.

After the courses are all placed in position and glued together, the straight face represented by *i' i'* on the outer edge and *k' k'* on the inner edge is worked off to the proper curves, the patternmaker being guided by the edges of the courses. When this is complete, the back of the blade is worked off to a templet, different templets having been made for several cross-sections, as, for instance, on the lines *l l* and *m m* in the plan shown in Fig. 1 (*b*).

While this pattern is shown built face down, with the ends of each course resting on the angle piece, it may be built face up, and, by some patternmakers, the latter method is preferred, because it is plain that they can see better to guide the face edges right when they are on the upper side than when they are on the lower, but this is only a matter of individual preference.

5. Practically all propeller wheels are constructed with a slight rake aft, and this has to be taken into account in building a pattern. To allow for this rake, it may be necessary to use one or more segments that do not extend to the hub, or to cut away the hub end of some of the segments after they are in place. Propeller wheels are also frequently constructed that do not have a constant pitch. In this case the pitch is specified for certain points, and the intermediate points are worked down so that the surface at one point blends into that at another without any sudden changes in form. To construct a pattern for a propeller wheel having a variable pitch, it is necessary to construct templets for several points at the face of the blade. Both in the case of propeller wheels having a constant pitch and in the case of those that have a variable pitch, some patternmakers construct a series of forms and build the pattern upon them. When this method is followed, a series of concentric circles is drawn on the board on which the pattern is to be built, and the angle for the blade at each one of these circles is calculated and a piece of metal cut out similar to the wooden form shown at Fig. 1 (*d*). Wooden guides are then sawed to the radius of the circles drawn and the metal forms fastened to these. The propeller wheel is then laid up, each succeeding segment being fitted against all the guides; after the pattern is built up, the material between the guides is worked off. This finishes the flat side of the propeller wheel. The form of the blade is then laid out upon this surface and the stock surrounding it cut away. In order to give the proper form for the other side, either one of two methods may be followed. In the first, a series of templets is made and the back of the blade worked down to these templets. In the second, the thickness of the blade at different points is calculated, small holes are bored through the blade at these points, and pegs are cut off to a length that will correspond to the thickness at these various points. These pegs are glued in the holes so that one end is flush with the flat side of the blade. After this, the other side of the blade is worked off flush with the ends of the pegs.

6. Molding a Propeller Without a Pattern.—Propeller wheels are also sometimes molded in loam, the lower face corresponding to $i' i'$ and $k' k'$, Fig. 1 (*b*), being swept up with the aid of a guide similar to that shown at Fig. 1 (*d*). The blades are then built up from molding sand by means of templets, after which the cope is rammed. The cope is then lifted, the molding sand occupying the place of the blades cleared away, and the mold made ready for casting. When this method is followed, the casting is really obtained from a sand pattern. As this matter interests the molder more than the patternmaker, no further description of it will be given here.

STOVE PATTERNMAKING.

STOVE MODELS AND DRAWINGS.

7. Stove Models.—When the manufacturer desires to bring out a new design of stove, the general scheme is usually first developed in the form of a drawing, but before deciding definitely on the exact form of the stove, a model is sometimes worked up in clay or plaster. This enables the designer to study the exact outline of the stove and see just how the various parts will fit together, and especially to study the general artistic effect. This method of procedure is especially advantageous in the case of heating stoves or stoves having considerable ornamental work on them. Plain work, such as that on cook stoves and ranges, is generally carried through without making the model. In case the design in hand has for its object the remodeling of an existing design, many of the castings of the old design will, if possible, be worked into the new design.

There are usually some castings that can be used on the stove, or some of the castings are made first and utilized in connection with the design. Fig. 2 (*a*) shows a stove in the process of being modeled. It will be noticed that some of the castings, such as the base and top, have a finished appearance, which indicates that they have already been decided on, and used in the model. For the purpose of supporting the remainder of the stove, a set of somewhat smaller stove castings and a sheet-iron drum are used. Sometimes it is necessary to model only one-half of the stove, especially in round work or in work that has two or more sides alike. In Fig. 2 (*b*) is shown the other view of the same model as that

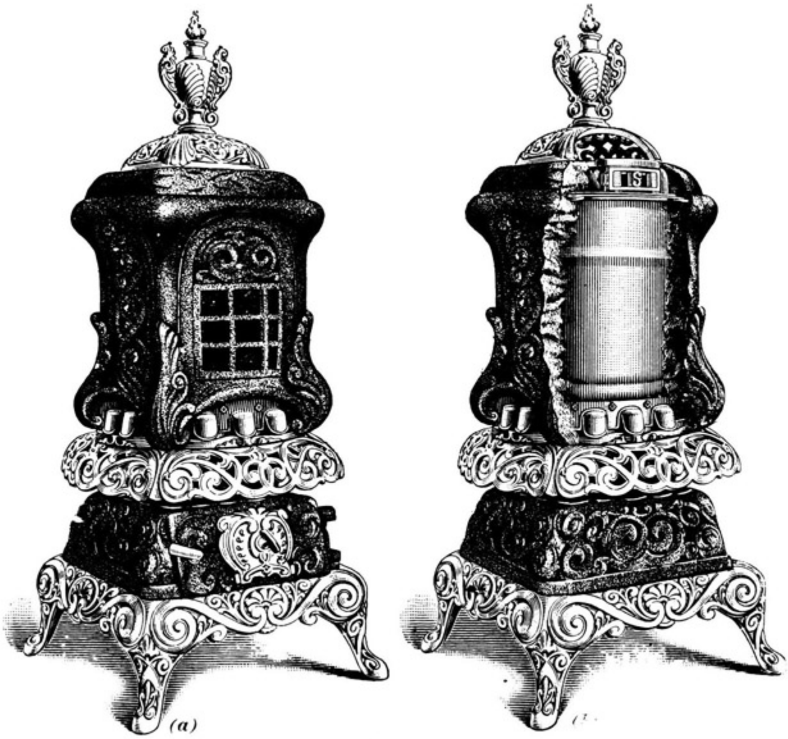


FIG. 2.

shown in Fig. 2 (*a*), with the two sides of the stove completely modeled. A specially prepared clay that dries very slowly is used for the modeling. The clay is applied as shown in Fig. 2 (*b*). After the model is completed, the drawings, which are usually only partially worked up first, are finished, and the patternmaker makes the patterns or completes those that are not already made. The modeling is usually done by a specialist in this work, who may also be a good draftsman.

8. Stove Drawings.—Stove drawings differ in a great many respects from ordinary mechanical drawings of machinery. The stove drawings are generally made full size. A good grade of detail paper that is but slightly affected by the moisture in the atmosphere is selected on which to make the drawing. The plan is usually laid down first, and from this the sections and elevations are projected and drawn as the idea develops. All views are placed one on top of the other, that is, the elevations and sections are all drawn on or across the plan, so that only a person thoroughly familiar with stove work can read one of these drawings rapidly. Usually the different sections are colored differently, and, as a rule, no dimensions whatever are put on the drawing. Most mechanical drawings have to go into the machine shop to have the machine made, some of the drawings going first to the pattern shop and some to the forge shop, but in the case of a stove drawing, it goes to the pattern shop only. The patternmaker prepares the patterns directly from the drawing. Wooden patterns are first made, and from these the iron patterns are cast, which serve for making the final castings of the parts of the stove. On this account, at least double the shrinkage usually allowed for castings must be allowed on the original patterns. In this work the stove draftsman uses a rule that gives the proper shrinkage, so that the patternmaker simply has to make the patterns the same size as the drawing. On account of the fact that drawings are generally made full size, they are always large, and in making them the draftsman usually works from one edge of the board only.

SPECIAL TOOLS USED FOR STOVE PATTERNMAKING.

9. Shrink Rules.—Stove patterns are all made of metal, and these metal patterns are made from other metal patterns called **master patterns.** It is therefore necessary to make the original wooden patterns with more than the usual cast-iron shrinkage allowance or with more than one shrink. In some cases the master patterns are made from white metal, which shrinks only one-half as much as iron, necessitating the use of a set of shrink rules, called *half-shrink rules.* In order to be able to make any kind of a pattern that may be called for, a stove patternmaker should have at least five rules, and they may have as many as seven. In case seven are used, they are one standard rule graduated to 16ths of an inch, and the following shrink rules: ½ shrink, 1 shrink, 1½ shrinks, 2 shrinks, 2½ shrinks,

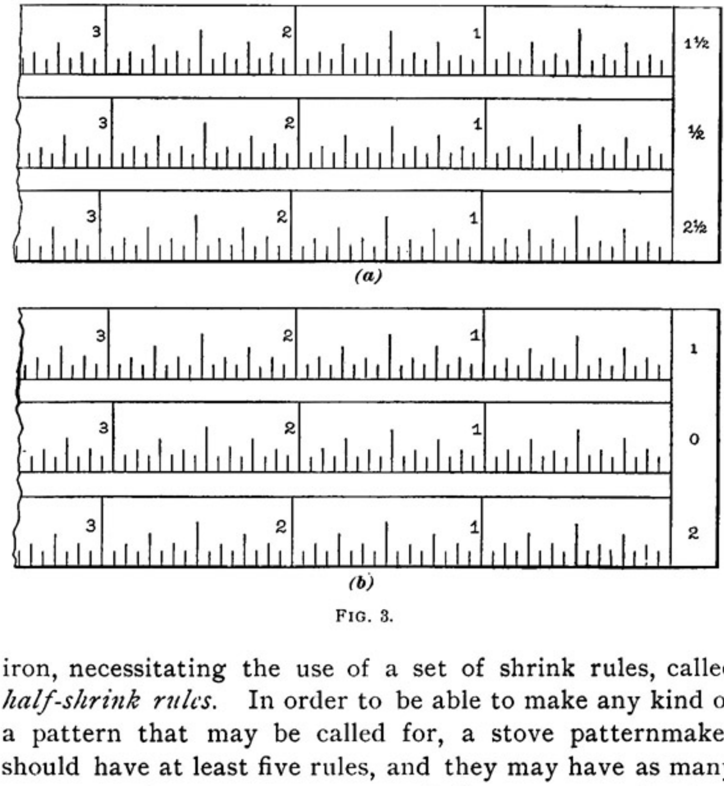
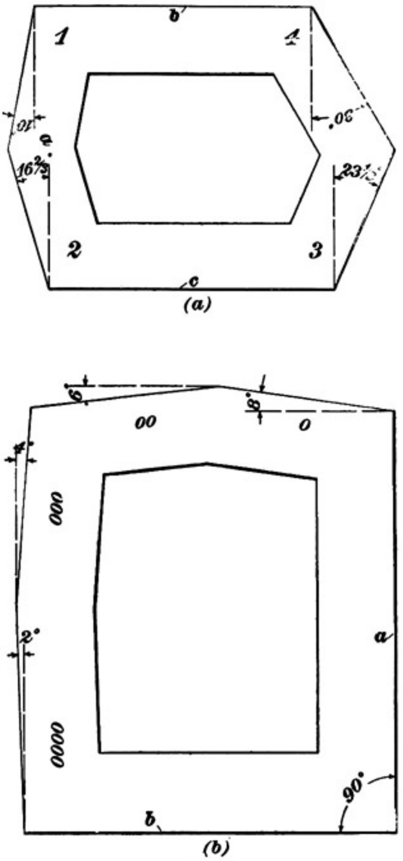


FIG. 3.

and 3 shrinks. In this connection a shrink is understood to mean the amount of shrinkage per foot in cast iron, which is $\frac{1}{8}$ inch. In constructing the first of these rules, that is, to produce the $\frac{1}{2}$-shrink rule, a space that is intended to represent 12 inches would be made $12\frac{1}{16}$ inches long. This would be divided into 12 equal spaces to represent inches, and these subdivided into 16ths. In like manner, any of the other shrink rules would be made by taking 12 inches plus the shrinkage allowance and dividing it into 12 parts and these into 16ths. These shrink rules are usually at least 24 inches long and are made of wood. Most of the measurements in stove patternmaking are taken by means of a pair of trams from the shrink rules; hence, the end of the rule is allowed to project beyond the graduations, as shown in Fig. 3. This illustrates a set of five shrink rules and a standard rule all made on one piece. In Fig. 3 (*a*), the upper rule is made for $1\frac{1}{2}$ shrinks, the next $\frac{1}{2}$ shrink, and the bottom one for $2\frac{1}{2}$ shrinks. The back side of this rule would be graduated as shown in Fig. 3 (*b*), the upper scale being for 1 shrink, the center scale a standard rule, and the lower scale for 2 shrinks. In order to avoid confusion, however, it is best to have each of the rules on a separate piece.

10. Stove Bevels.—Where the various plates that compose the stove are united, the edges of the plates are usually beveled. One plate has to be beveled so as to match the bevel of the other, so that they may come together properly. Stove patternmakers have found it advantageous to have a set of bevel gauges so that these bevels shall be uniform. Mr. Nicholas Vedder, formerly a stove designer and patternmaker of Troy, N. Y., originated a set of bevels that have come into quite extensive use among stove manufacturers. There are eight of these bevels, although at first only four were laid out, and they were numbered *1*, *2*, *3*, and *4*, as shown in Fig. 4 (*a*). Subsequently experience showed that other bevels would be advantageous; hence, the space between the No. 1 bevel and the vertical line *a* was divided into five equal spaces, thus giving four more bevels, which are made and numbered *0*, *00*, *000*, and *0000*, as shown in Fig. 4 (*b*). The bevels are shown in Fig. 4 with the angle of each bevel marked in degrees. For convenience in use, these bevels are ordinarily made of thin wood or metal pieces similar to the triangles used in making mechanical drawings. Fig. 4 (*a*) and (*b*) shows the two of these gauges in most common use by stove patternmakers and draftsmen. In using the gauge, Fig. 4 (*b*), the draftsman places one of the straight sides *a* or *b* of the gauge against a **T** square and then draws the desired lines along the bevel side corresponding to the bevel he wishes to use. In the form shown in Fig. 4 (*a*), the two opposite sides *b* and *c* are parallel and are used against a **T** square in laying off the bevels. These bevels, or gauges, are made of any convenient size.



(*b*)

FIG. 4.

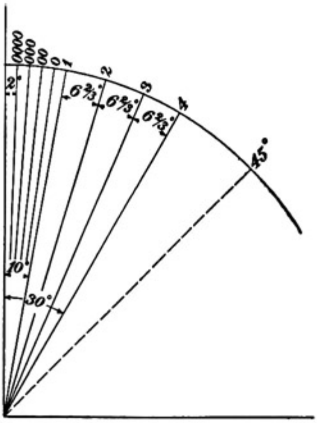


FIG. 5.

The number of the bevel only is put on the gauge; the degrees have been added in the illustrations to make clear the angle of each. Fig. 5 shows how the angle would look if laid off successively from the least to the greatest.

11. Stove-Patternmakers' Curves.—In a great deal of stove work, especially in heating stoves, some of the surfaces are curved. These curves are usually regular curves, but on account of the fact that it would be very inconvenient indeed to use trams in constructing these curves, Mr. Vedder also brought out a set of curves drawn with standard radii. To these curves he gave arbitrary numbers as follows: $2\frac{1}{2}$, 3, 4, 5, 6, 7, 8, 9, and 10. They are usually made with the general form shown in Fig. 6. The length *b* is the same on each one of an entire set, while the distance *a* has values that are different on each one, varying according to the radius of the desired curve. The value of *a* is greatest on No. $2\frac{1}{2}$ and least on No. 10. On a set actually measured *b* was $22\frac{15}{16}$ inches and *a* was 2.28 inches for No. $2\frac{1}{2}$, 1.86 inches for No. 3, 1.34 inches for No. 4, 1.09 inches for No. 5, .91 inch for No. 6, .81 inch for No. 7, .69 inch for No. 8, .61 inch for No. 9, and .55 inch for No. 10.

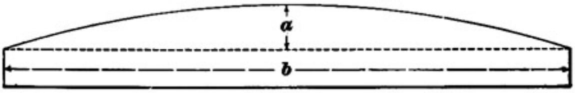


FIG. 6.

These curves may be made from thin wood or from sheet metal. It is best to make them of metal on account of the fact that metal is not so liable to change its shape. Like the bevels, they are used by both the draftsman and the patternmaker.

12. Vertical Plumb.—In stove patternmaking it is frequently necessary to draw a center line over an irregular surface, and in order to do this a device known as a **vertical plumb** has been invented. This is illustrated in

Fig. 7, and consists of two boards *a* and *b* secured to each other at right angles and held in position by braces *c*, *c*. The outer faces of the boards *a* and *b* are carefully planed at right angles to each other. For use in connection with the plumb, a pair of wooden parallel blocks *d*, *d* is provided. The casting or pattern on which the center line is to be placed is laid between the parallel blocks and under the board *b*, as shown in Fig. 7 (*a*). A special scriber, as shown at *e*, is used for drawing the center line. This scriber consists of a piece of hard wood *e* with a steel scribing plate attached to the end, as shown at *f*, Fig. 7 (*b*). By means of this device it is possible to draw a straight center line across a piece of work, no matter how irregular it may be, or how much carving there may be on its surface.

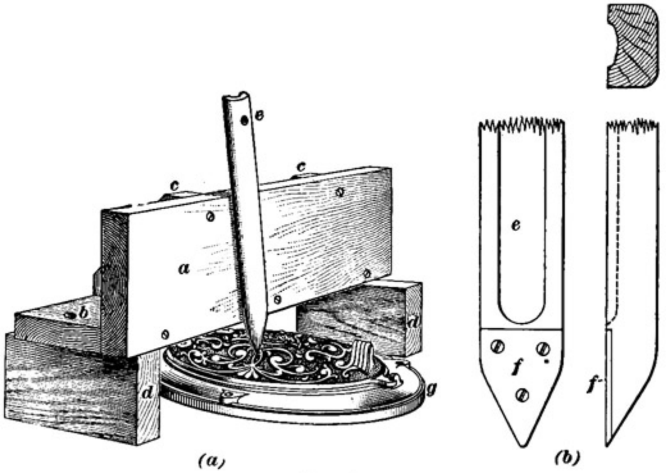


FIG. 7.

13. Thickness and Marking Calipers.—Stove patterns have to be carved very thin, and it is necessary that the patterns be of uniform thickness throughout, for if this is not the case, some parts of the casting will cool more rapidly than others and result in the springing or cracking of the casting. Most stove-plate work is more or less irregular in outline, and in order to make sure that the thickness at different points is the same, various forms of calipers are in use for measuring the thickness. Fig. 8 (*a*) shows a simple stove-patternmaker's caliper, which consists of two brass castings joined together like a pair of ordinary shears. The measuring is done with the points shown at *a*, while an adjusting screw is placed as shown at *b*. This screw *b* is so adjusted that when it comes in contact with the other portion of the handle, the points

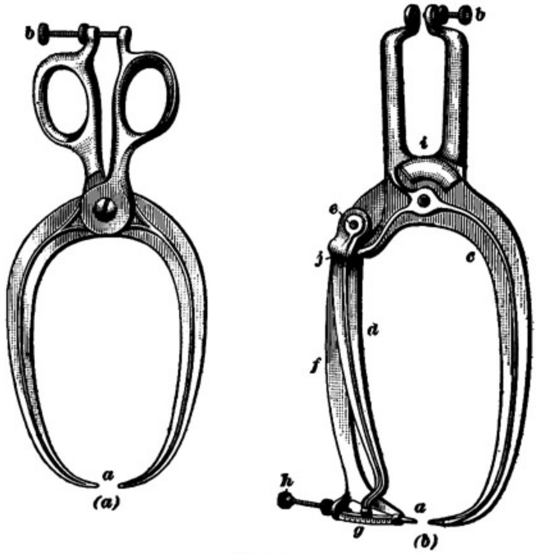


FIG. 8.

at *a* will stand at the desired distance apart. By passing the points *a* over the work, the patternmaker can see what parts have been brought to the desired thickness. Any parts that are not thin enough will prevent the screw *b* from coming in contact with the other leg of the handle and so indicate what portions of the pattern must be carved thinner. For somewhat more accurate work, a pair of calipers of the form shown in Fig. 8 (*b*) may be used. These calipers are made of aluminum, and are provided with steel measuring points as shown at *a*. As in the previous case, an adjusting screw *b* is provided at the back end of one of the handles. A spiral spring is located in the pocket *i* and keeps the points of the calipers apart unless they are brought together by hand. This caliper is also provided with an attachment for indicating the exact amount of excess thickness at any point. This is done with an extra arm shown at *d*, pivoted at *c* to the arm *f* of the calipers. A projection on the arm *c* comes in contact with the arm *d*, and a spring located at *j* keeps the arm *d* in contact with this projection. As the points of the calipers are brought together, the point *g* of the arm *d* is forced up along the graduated scale shown on the arm *f*. An adjusting screw *h* is provided for stopping the arm *d* when the points at *a* are the desired distance apart. The leverage is so arranged that the point *g* moves several times as far as the point *a*, and, as a consequence, registers any variation in the thickness of the pattern very accurately.

14. When the front side of a stove pattern is carved into scrollwork, and it is necessary to back out, that is, cut out,

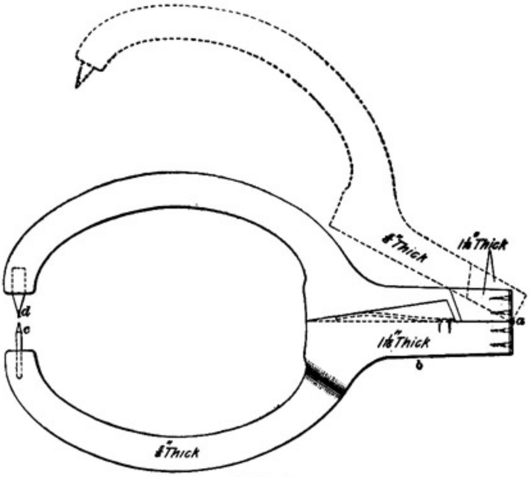


FIG. 9.

the pattern behind this scroll, it is convenient to be able to trace the scrollwork on the back of the pattern. In order to accomplish this, a pair of **marking calipers,** as shown in Fig. 9, is used. They are made of hard wood and are joined with an ordinary hinge at *a*. The hand grasps the two pieces at the point *b*, with sufficient pressure to bring them together, although a flat spring in the joint tends to keep them apart. The point of one caliper leg is provided with a steel tracing point *c*, and the other is provided with a lead pencil *d*. By following the outline of the carving with the point *c*, and keeping the pencil *d* in contact with the back of the pattern, the outline of the carving can be transferred from one side of the pattern to the other very quickly and accurately.

15. Chute Board.—Many portions of a stove pattern have to be joined on an angle, and as the pattern stock is very thin, it is extremely difficult to plane the edges of the pieces to the proper angles, without some special device for holding the work. To accomplish this, the **chute board,** one form of which is illustrated in Fig. 10, is usually employed. It consists of a flat board or gauge *a* on which the plane *d* slides, resting on its side, as shown in the illustration. An inclined board, as shown at *b*, is so arranged that it can be adjusted so as to make any desired angle with the board *a*, and a stop, as shown at *c*, is provided for holding the end of the work. The work or stock to be operated on is laid on the board *b*, brought against the stop *c*, held there by hand, and the edge dressed to the desired angle by means of the plane *d*.

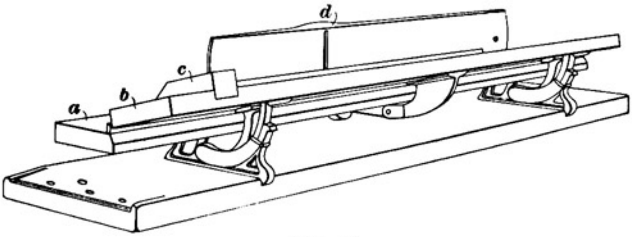
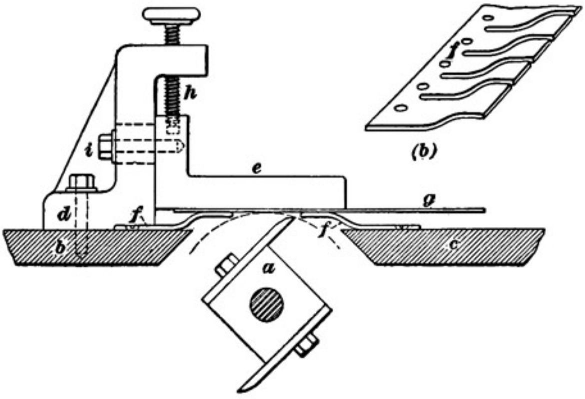


FIG. 10.

16. Carving Tools.—In stove patternmaking, a large amount of carving is necessary, which could not be done advantageously with the chisels in an ordinary patternmaker's outfit. Hence, the stove patternmaker has to provide himself with a series of carving tools, which usually consist of 18 or 20 small chisels in the form of gouges, paring chisels, and gravers. In large stove-pattern shops the carving is usually done by men especially skilled in this work, and in some cases a stove pattern passes through the hands of three or four men, each doing his own special work.

17. Planer Attachment for Making Thin Stock. In stove patternmaking it is necessary to use a great deal of very thin stock, some of it being less than $\frac{1}{12}$ inch in thickness. In order to produce this thin stock on an ordinary planer, some special attachment is necessary, and the one shown in Fig. 11 has been used very successfully. At *a* is shown the cutter head of the planer, and at *b* and *c* the ordinary cast-iron tables. On each side of the table *b*, an angle bracket $2\frac{1}{4}$ inches wide, shown at *d*, is fastened, and between these two angle brackets the angle plate *e* is supported. This angle plate is clamped to the brackets by the clamp screws *i*, and can be adjusted vertically by two $\frac{3}{4}$-inch adjusting screws *h*. In order to hold the stock being operated on in contact with the angle plate *e*, the springs *f*, *f* are



(a)

FIG. 11.

attached to the tables *b* and *c*. A detail of one of these springs is shown at (*b*). It consists of a piece of spring steel that is shaped to the desired form and tempered. The edge of the spring is split in such a way as to form a series of carrying springs, each about 1 inch wide, which hold the work in contact with the angle plate *e*. By this device it is possible to plane thin stock smoothly to a uniform thickness with very little trouble, and the form of the attachment avoids all danger of injury to the workman's hands.

CHARACTER OF STOVE PATTERNS.

18. Comparison of Stove Patterns and Ordinary Patterns.—Ordinary patterns for machine parts are usually fairly thick and stiff enough to support themselves. The skilful application of the principles of joinery in the production of the desired form plays an important part in the work of a machine patternmaker. Stove patterns, on the other hand, are usually very thin and must be practically of uniform thickness throughout, and as a consequence such patterns require special treatment. Stove patterns are rarely stiff enough to support themselves; hence, for all but small parts of the stove it is necessary to have a match or support for the wooden pattern for use while making the metal pattern. In many cases the match is made first and the wooden pattern is then made on the match. These patterns are frequently very intricate, having a large amount of carving on them. On account of all these facts, stove patternmaking differs greatly from ordinary patternmaking and is a peculiar branch by itself. There are, however, many points concerning stove patternmaking that the ordinary patternmaker could use with advantage when producing thin or intricate patterns.

19. Materials Used for Stove Patterns. — The original pattern used for stove work is usually made of wood, but in some cases it is modeled in clay or plaster. From the original pattern a metal pattern is usually made as a master pattern, which is to be preserved. The wooden patterns cannot be preserved and relied on for future work on account of the fact that they are so thin and delicate that they are almost sure to change their shape. Some foundries make their master patterns from iron, and others make them of a white-metal alloy, this white metal consisting of 9 parts of lead to 1 part of antimony, and having a shrinkage of $\frac{1}{16}$ inch per foot. Particular attention, however, is called to the fact that in order to obtain uniform results one brand of lead and one brand of antimony must be adhered to, as different brands have different physical properties. It does not make so much difference what brand is adopted, but one should adhere to the brand first adopted. After the master pattern has been made, and the ordinary working patterns of iron are made from it, the master patterns are preserved in a suitable room or storage. In some cases they are kept in fireproof vaults, as they become the ultimate standards of reference in relation to any given stove.

PROCESSES USED IN MAKING STOVE PATTERNS.

20. Carving and Backing Wooden Patterns. The simplest method of making a stove pattern is to carve it from wood, backing it out, that is, carving out the back so that it is of uniform thickness throughout. If the pattern is small, like a stove leg, it is not always considered necessary to make a match for it, but the pattern may be tucked up in sand, that is, a sand match may be tucked up for the pattern and the master pattern made directly from the wooden pattern. In the case of all the larger patterns, it is necessary to carve an accurate match that will fit the patterns at all, or practically all, points, and support it while ramming up the drag of the flask when making the master pattern. In the case of regular work, such as stove bases, etc., the match is usually made first and the parts of the pattern laid on it. The joints are glued together, and the pattern is kept in contact with the match throughout all the work. The match is oiled at any point where glue is used in the pattern, in order to prevent the glue from adhering to the match. After the pattern and match are completed, the iron pattern is made, when both match and wooden pattern are discarded.

21. Carving and Blocking a Wooden Pattern. In order to avoid the work of backing out a pattern, a system is quite frequently employed in which the face of. the pattern is carved and finished to the desired shape, and then the casting produced by so blocking the pattern on a board that a drag can be rammed up from it. This drag is then used as a match, and a cope is rammed up in the usual manner. While the original drag was being rammed, the pattern was surrounded with a thin layer of blocking just the thickness of the desired casting. This blocking is removed and another drag rammed up to be used with the cope already made. By this method the pattern is made to project farther from the molding board in the second case, so as to produce the required thickness of metal. This process will be thoroughly illustrated in connection with a stove pattern later on.

22. Wax Process to Avoid Backing.—In some cases, in order to avoid backing out the pattern, one side only is carved, and from this a plaster-of-Paris cast is made. The pattern is then built up on this cast by pressing some material of uniform thickness into the space covered by the pattern. This is usually accomplished by rolling clay into a thin layer of the desired thickness, cutting it into small strips and pieces, and fitting these into the area covered by the pattern. After the pattern has been built up in clay on the plaster match, the surface of the plaster and the clay is prepared with oil, and the other half of the mold poured in plaster. The two portions of the plaster mold are then taken apart and the filling material cleaned out. Gates and vents are cut, and a hard-wax pattern made by pouring the space between the halves of the plaster mold full of hard wax. After this, either half of the plaster mold may be used as a match board to support the wax pattern while preparing the sand mold for a metal pattern.

EXAMPLES OF STOVE PATTERNMAKING.

BASE PANEL BY THE BLOCKING PROCESS.

23. The Block Pattern.—The **blocking process** is used by many stove patternmakers for producing metal patterns. As far as the actual work of the patternmaker is concerned, patterns may be made by this process much more simply and with a great deal less work than by the ordinary method of procedure. The first outline pattern made of wood is called a **block pattern,** and is made with 2 shrinks. The drawings for such patterns should be made with measurements taken from a 2-shrink rule, as this will greatly simplify the work of the patternmaker, who also uses a 2-shrink rule. For the block pattern, the best of pine should be chosen, except for the scroll ornamentation, which may be made of mahogany. Pine, being a soft wood, splits and crushes easily, while mahogany, being a medium hard wood, cuts easily and retains the edges given it by carving tools better than pine. For this reason mahogany is preferred for those parts of wooden patterns on which carving must be done. By carefully selecting the stock, a good deal of very delicate carving can be done on pine patterns, and hence some good stove patternmakers use no mahogany.

24. Preparing the Block.—A block composed of pieces glued together is first made of the required length, width, and thickness, which may be 36 inches by 8 inches by 2½ inches. In Fig. 12, the joining of the pieces for the blocks is shown at *b*. In the case illustrated, eight strips 36 inches long, 2½ inches wide, and 1 inch thick, have been glued together to form the block from which the pattern is to be made. The block is made in this manner to prevent the pattern from warping or getting out of shape. Wood changes its shape from time to time when exposed to the atmosphere, and while the gluing of the pieces does not prevent them from changing, yet the pattern as a whole retains its shape much better than when made of a solid block. After the glue has dried, the block is squared up on all sides and is then ready for the outline of the design.

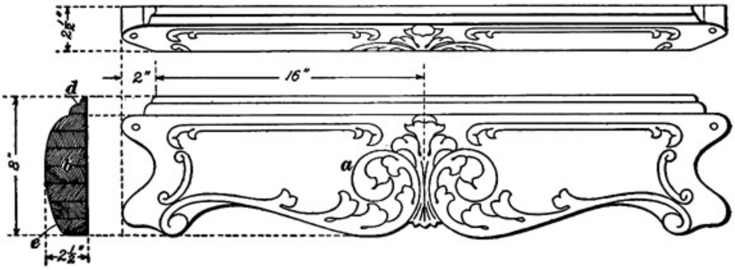


FIG. 12.

25. Laying Out the Scroll.—In laying out the section of the pattern on the block, the first thing to do is to trace the shape of the molding and swell, by the use of carbon paper, on a thin piece of board or metal, large enough to cover the end of the section of the panel, as shown at *b*, Fig. 12. The entire outline of the end of the pattern from the top of the molding *d* to the bottom of the swell at *e* must be carved out of the piece of board or metal, so that it can be used as a templet to lay out the outline of the figure on each end of the block with a sharp hard pencil. When the form is laid out harmoniously on both ends, the block can be cut into shape by the use of molding planes. The pattern is now ready for the addition of the ornamentation, which is a scroll of the design shown at *a*. A mahogany strip large enough to take the entire scroll is then prepared, which is laid out directly from the drawing. The mahogany piece should be thick enough to take all the carving, but need not be any thicker, as it is a rather expensive wood. A thickness of $\frac{3}{8}$ inch is sufficient to give good relief in the carving, and is not so deep that it will interfere with the molding of the piece in the sand, provided easy drafts are given to the pattern. By *easy draft* is meant that the top edges of the pattern should be enough smaller than the bottom edges to allow the pattern to draw out of the sand freely. In Fig. 13 is shown a section of the pattern with proper draft given to all the faces. The bottom surfaces of the mahogany pieces are shaped to the various swells and curves of the pine part of the pattern by rubbing blue chalk on the parts of the pine pattern where the scrolls are to be glued. The chalk blues the mahogany just where it touches the pine and thus shows where the material should be cut away to insure a more perfect fit of the pieces. When the proper fit is obtained, the unnecessary parts are removed and the pieces glued and fastened to the pine pattern. The scroll is then laid out and the carving done. It is the finishing strokes on the pattern by the trained hand of the expert carver that give life and relief to the panel.

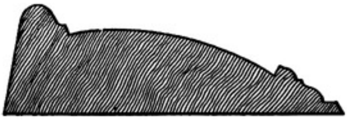


FIG. 13.

26. Finishing the Wooden Pattern.—When the carving is completed, the pattern is prepared for the mold by applying three coats of shellac to the surface of the pattern, with sandpapering between to give a smoother finish. After the first coat of shellac has dried and been sandpapered, the brad holes and other small holes are filled with beeswax and the second coat of shellac applied. When that is dried, the surface is again sandpapered and shellaced, which is the final operation. When dry, it is ready for the molder to make the metal pattern. This operation is frequently called *reversing the pattern.*

27. Preparing the Pattern for Reversing.—The term **reversing the pattern** means the process by which the molder changes the block pattern into an iron-shell

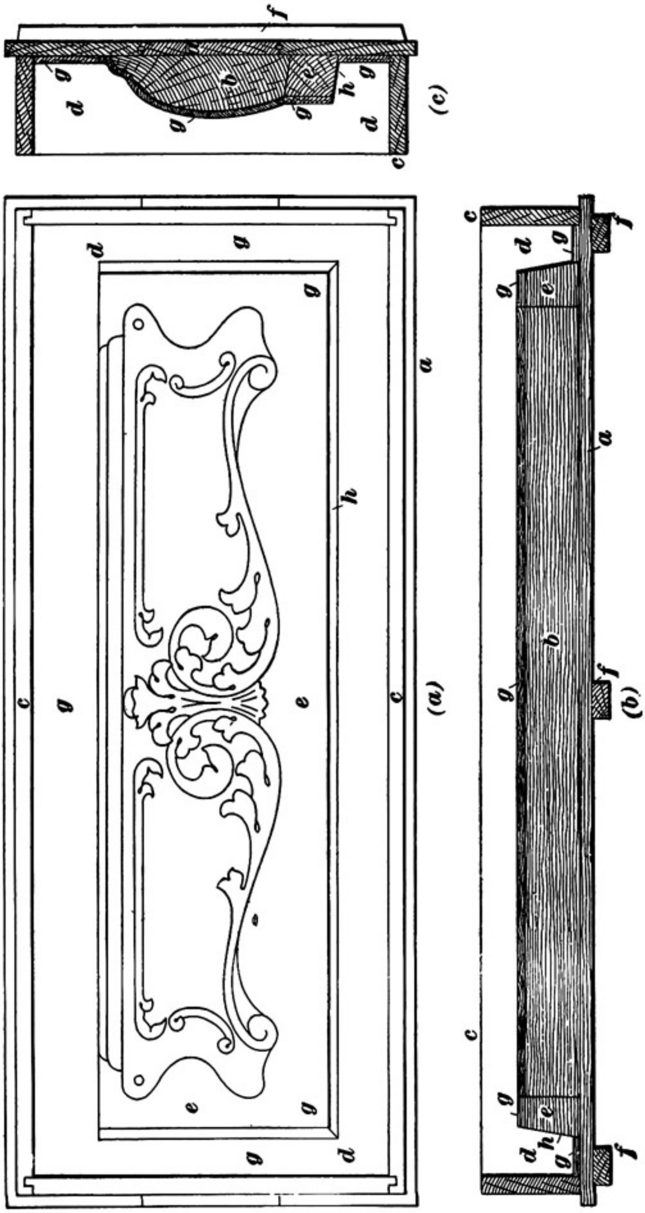


FIG. 14.

pattern of uniform thickness. The first step in the process is the making of the pattern board, as shown at *a*, Fig. 14. The pattern shown here is the same as that shown in Fig. 12. The pattern board is made with an allowance of 3 or 3½ inches at each end and at the top, outside of the pattern; but at the bottom the allowance is 4½ or 5 inches. This margin around the pattern *b* is left to allow for the flask shown at *c*, the sand space shown at *d*, and for the blocking shown at *e*. The pattern board is made of two or three pieces of 1⅛-inch lumber fastened together with three cleats nailed to the bottom side, as shown at *f*. After the boards are nailed securely to the cleats, the nails should be set and the top of the board trued and leveled, as much depends on the accuracy of the board in these respects. Next, the pattern is fitted to position on the board and fastened there by two or three screws from the under side of the pattern board. The required iron pattern is to be of the uniform thickness of ⅛ inch. The upper surface of the blocking *e* is made just ⅛ inch lower than the top of the pattern. The blocking fits the pattern on three sides, and is given plenty of draft on its outer edges, as shown at *h*. On top of the blocking and the pattern board thin pieces ⅛ inch thick, called thickening, are fastened, as shown at *g*. The *thickening* is stock planed to ⅛ inch and tacked all over the horizontal surfaces of the pattern board and blocking, but not on vertical surfaces, and brings the top of the blocking up to the face of the pattern, as shown in Fig. 14 (*b*) and (*c*).

28. The Process of Reversing.—When the blocking and thickening are in place, the pattern and pattern board are ready for the flask. The *drag* is the lower part of the flask when the mold is cast, and contains the sand in which the impression of the face of the pattern is made. The *cope* is the upper part of the flask in casting, and contains the sand in which the impression of the back of the pattern is made. Flasks are provided with dowel-plates and dowel-pins to hold the cope and drag in the proper relation when put together after having been separated.

The pattern, pattern board, blocking, and thickening being all ready, the drag is placed upside down on the pattern board and thickening. Fine sand is sifted all over the pattern, and then the drag is filled up with heap sand rammed hard, and struck off in the usual manner. A bottom board is placed on top, rubbed down to a firm bed on the sand and flask, and the whole clamped together and rolled over. The clamps are removed, and the pattern, which is now upside down, is ready for removal. The pattern board is loosened from the flask and sand by wedges placed between it and the flask. When the pattern is started squarely all around, it is lifted off by hand and leaves in the drag an impression of the face of the pattern. The cope of the flask, which has ribs in it crosswise with edges projecting to within about $\frac{3}{4}$ inch of the pattern, is placed on the drag. Parting sand is then sprinkled all over the drag, and whatever does not adhere to the moist mold is blown off with a bellows. The sprue pins, which are conical pieces of wood, are set on one or more parts of the flat sand face of the mold, not on the pattern. These sprue pins are as long or a little longer than the cope is deep, so that when the cope is filled up with sand they can be withdrawn, leaving holes through the cope for the metal to enter. When the cope part of the mold is completed, it is lifted off and placed to one side. The drag is shaken out because it is necessary to make a new one with the thickening removed from the pattern board and blocking. By removing this thickening the second drag is made $\frac{1}{8}$ inch deeper than the first on the horizontal planes, but the curved or vertical parts will not be $\frac{1}{8}$ inch thicker. This is illustrated in Fig. 15, where *a* is lifted above *b*, giving a $\frac{1}{8}$-inch space where the lines are horizontal, but approaching nothing as they approach the vertical. In order to have a $\frac{1}{8}$-inch space on the sides, it is necessary to cut away the sand

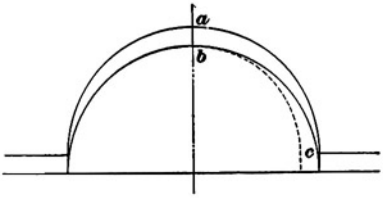


FIG. 15.

of the mold along the dotted line *b c*. This same operation must be performed in the mold for the piece shown in Fig. 14, and it requires great care and good judgment to cut away the sand so as to give the exact ⅛-inch thickness to the curved parts of the mold. The second drag part of the mold is made in the same manner as the first; the sand is removed as just described and gates cut from the sprues so as to form shallow passages for the iron on its way to the mold. Leaving the drag on the bottom board, the cope is now placed on the new drag, and when clamped down appears as shown in Fig. 16, which is a section of the mold. The impression of the pattern is shown at *a*, the gate at *b*, the sprue at *c*, the sand at *d*,*d*, the cope part of the flask at *e*, the drag part of the flask at *f*, the clamps at *g*, and the bottom board at *h*. The mold is now completed and ready to cast a metal pattern for the panel. After the metal pattern is cast, it is finished by filing and scraping and then varnishing. It is necessary to make a wooden match board for the pattern to keep it from springing during molding. A plain molding board is made, a piece of wood fastened to it and carved to approximately the shape of the under side of the pattern. Blue chalk is then rubbed on the pattern and it is fitted on the match board. The chalk marks the high parts, which require additional carving. By repeating this, the pattern is brought to a perfect bearing on the match board.

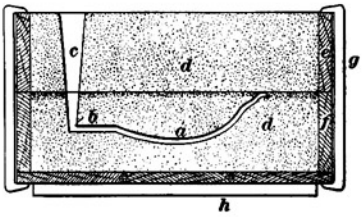


FIG. 16.

STOVE LEG BY THE BLOCKING PROCESS.

29. Preparing the Stock.—Prepare a block of mahogany as long as the leg is to be high, and as square as the fulness of the leg requires. The block should be made of 1-inch stock glued together, as indicated by the parallel lines in Fig. 17. When the block is made and squared up on all sides, it is to be split diagonally with a saw and glued together again as shown by the dotted line *a b* in (*b*). The reason for splitting diagonally and gluing together again, is to establish a center line all through the block for convenience in making measurements. No matter where a cut is made in shaping the face of the pattern, the diagonal joint line will be present as a center line.

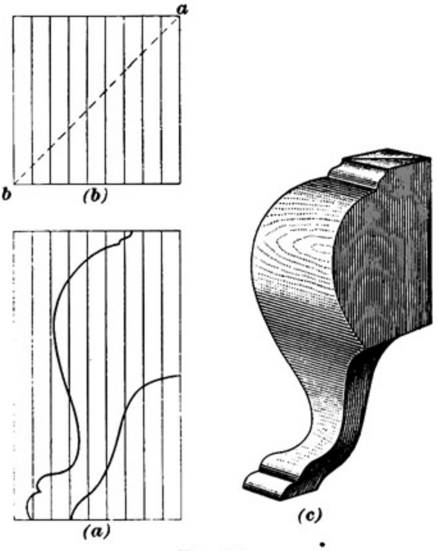


FIG. 17.

30. Forming the Leg. — Having completed the block, trace from the drawing the outline of the leg on two sides of the block, as shown in (*a*), at right angles to each other, and proceed to saw out from one side. By so doing the saw will cut into lines on the other side, and when the pieces leave the block they should be tacked back temporarily and the second side sawed. Then, after removing all the tacks, all the waste parts will fall off, leaving the leg in the shape shown at (*c*).

Continue to shape the leg, principally with the gouge and the spoke shave, using a templet of the leg as a guide. The back corner of the block is the axis of the center corner of the range or stove body, and is shown at *a*, Fig. 17 (*b*). All projecting parts of the pattern are measured from the center line, which is sometimes called the *45° line*, of the leg. The lower sides of the leg are shaped to conform to the ends of base panels.

The *grace lines*, as they are called, are given to the foot of the leg according to the width at the point *a*, as shown in

Fig. 18 (*a*), and the sides of the leg are shaped to meet the design of base panels.

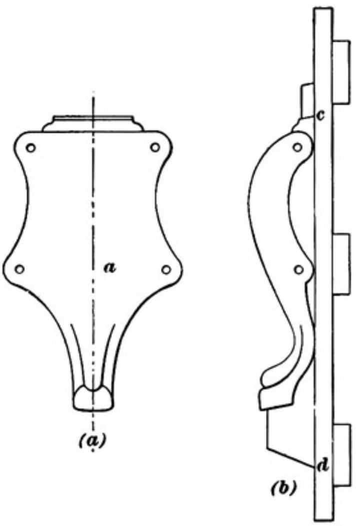


FIG. 18.

In shaping the pattern, care should be taken to leave the proper thickness of stock for carving the ornamental part, which should be about $\frac{3}{16}$ or $\frac{1}{4}$ inch. The depth of the carving cannot be as great on a leg as on the panel previously considered on account of its shape, making it difficult to give draft to deep carving. To prepare a leg pattern to be fastened to the pattern board, the back corner is cut away to as near the finished line as possible, as shown at *c d*, Fig. 18 (*b*), so as to have the projecting parts as near the same height above the pattern board as possible.

31. Blocking the Leg.—This pattern is blocked on the pattern board, as shown in Fig. 18 (*b*), for it is to be reversed, the process being the same as for the base panel. This leg pattern is made with a 3-shrink rule, because it is to be molded on a match plate, which is a plate of iron on which two leg patterns are cast, so as to make two legs at one ramming on in one flask. Hence, there would be 1 shrink for the reverse from the block pattern, 1 shrink for the match plate, and 1 shrink for the finished casting.

STOVE-LEG PATTERN AND BASE PANEL BY THE BACKING PROCESS.

32. Stove-Leg Pattern.—The term **backing** comes from the method of making the pattern by carving out the back to resemble the front of the pattern and thus making in wood a finished pattern of the piece having a uniform thickness. The front of the leg, with scroll or whatever figure it may have, is carved out first, as shown at *e*, Fig. 19 (*a*). This pattern may be made entirely of pine, the piece being glued up, the stock cornered, and the sawing done as described in Arts. **29** and **30.** The back, shown at *f*, is still to be removed. At *d*, Fig. 19 (*b*), the same pattern is shown partly backed out, and at (*c*) the backing has been completed.

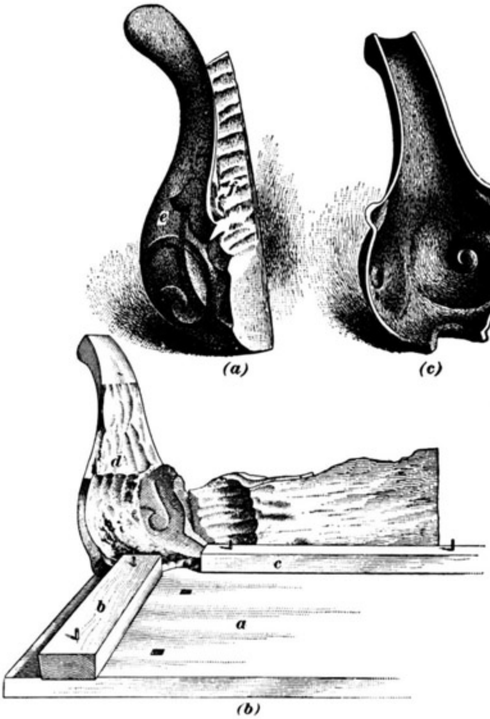


FIG. 19.

While backing out the pattern it is held in the left hand, while the patternmaker holds the carving tool in the right as he manipulates it in and out of the curves, as shown in Fig. 20. Experience and judgment have taught the workman what shape the casting will have, so that the pattern can be made to overcome any warping tendency by giving it an opposite curve. The marking calipers previously explained are used to trace the figure of the carving on the back from the front. When the back is carved as near to the correct size as can be with the eye, the thickness calipers are used to locate any thick places, which are then brought to the required thinness. Soon after this pattern has been completed, a white-metal master pattern is made from which the iron patterns are molded and cast.

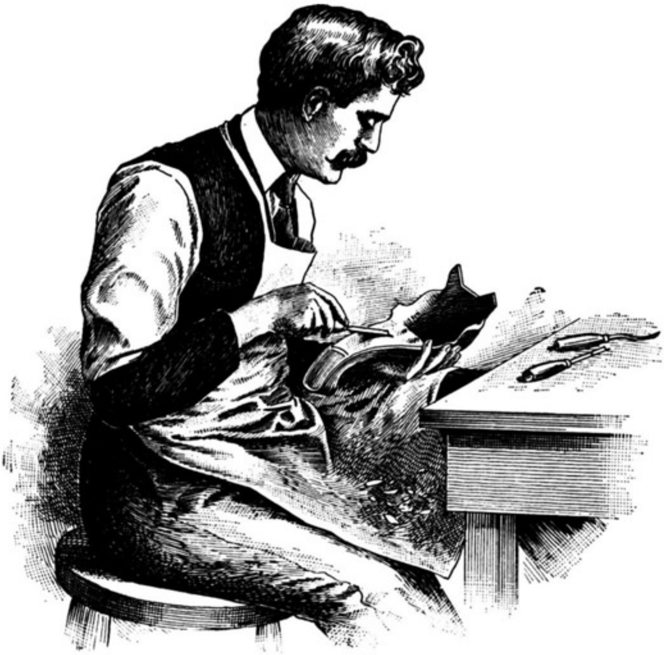
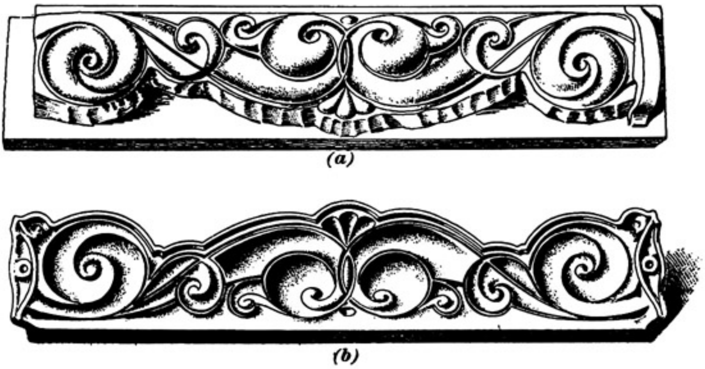


FIG. 20.

33. Base-Panel Patterns.—The stock for the front base panel is glued up and worked to the general form of the panel, as described in Art. **24.** If the block is made entirely of pine, allowance for carving must be made when working the block down to the general shape of the panel. The front panel of the base is carved out in the same manner as the leg, and is shown at Fig. 21 (*a*). This must be trimmed around the outside, which is usually done on the band or jig saw, and then backed out in the same manner as the stove leg. At (*b*) is shown the back of the same panel, showing how the pattern is backed out to the outline of the front or face side. This panel is fitted to the leg patterns by rubbing blue chalk on one pattern and then rubbing the patterns together to show where the trimming must be done to bring them to a good fit. The device shown in Fig. 19 (*b*) will be found useful in doing this work. It consists of a base board *a* on which two strips *b* and *c* are secured at right angles to each other. The leg is placed at one corner, as shown at *d*, and the panels placed against the strips *b* and *c*. The use of this device secures not only an accurate fit, but makes it easy to produce a base with square corners.


(*a*)

(*b*)

FIG. 21.

MAKING A PATTERN FOR THE FRONT JAMB OF A RANGE.

34. Preparing the Pattern Board.—The front jamb of a range is the part where the oven door is located. Such a jamb is shown in Fig. 22, with the elevation at (*a*), a section on *a b* at (*b*), and a section on *c d* at (*c*). The first step in the process of making the pattern for this jamb is to make a pattern board, on which the pattern is to be fastened, 3½ inches larger all around than the pattern. This board should, if possible, be made of 1⅛-inch pine boards

5 inches wide, that have been thoroughly seasoned or kiln dried. If wider pieces are used, saw cuts should be made two-thirds of the way through the boards and sufficiently close together to allow the board to be easily bent to the desired shape. Three cleats are then nailed to the boards, five nails being used to fasten each board to each cleat, as shown at *a*, *a*, Fig. 23 (*a*). The casting made from a straight pattern often comes out warped or with a bend in it, and so it is sometimes necessary to bend the pattern in the opposite direction so that the casting will come out straight. In such a case the mold board shown in Fig. 23 is arranged with bolts, shown at *b*, *b*, through the cleats and pulling against a curved piece shown by the dotted lines, so as to

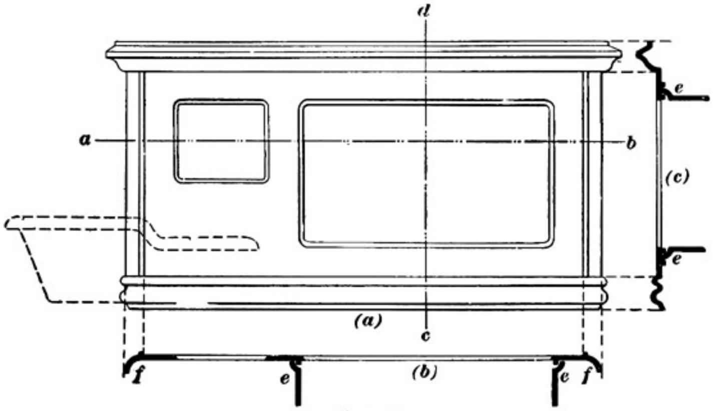


FIG. 22.

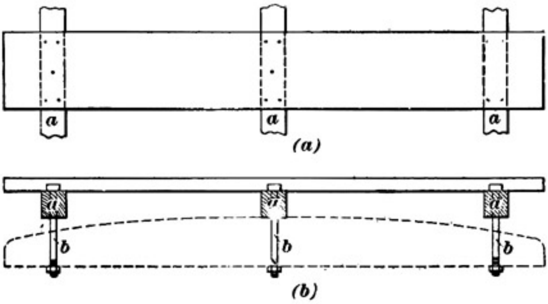


FIG. 23.

give the mold board the desired shape. This same method is used to prevent the pattern from warping after coming in contact with the wet sand. Before putting the pattern together on the pattern board, the pieces are all prepared so that they may be put on in a short time.

35. Preparing the Moldings.—A number of thin pieces, 4 inches wide and $\frac{1}{10}$ inch thick, of different lengths, are prepared, special care being taken to have all the thin parts just $\frac{1}{10}$ inch thick. The straight moldings for the sides and ends are then made, and a piece of the same cross-section turned for the corners. This is done for each different style of molding, and the turned pieces are each cut into four pieces. Each turned piece is made as shown in Fig. 24 (*a*), where *a* shows the entire piece, and *b* a half-section of it. The pieces *a* are then cut into quarters along

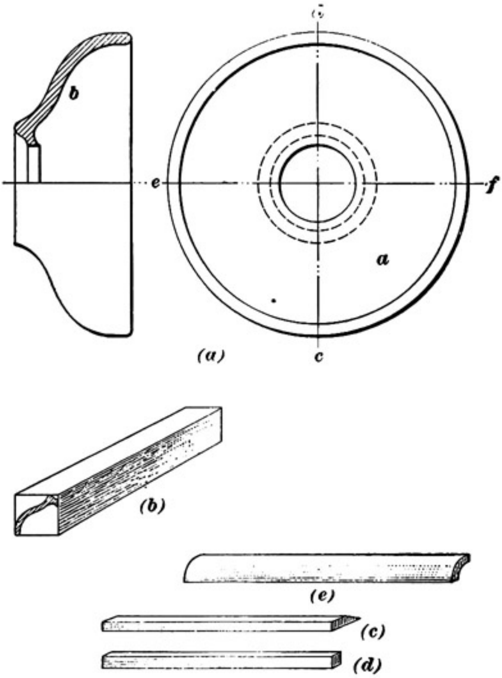


FIG. 24.

the lines *c d* and *c f*. One of these quarter pieces can be used as a templet by which to lay out the straight moldings.

To make the straight moldings, prepare pieces of the proper length, thickness, and width, according to the dimensions given on the drawing. Lay the templet on the end of the piece, mark around it with a fine hard pencil, as shown in (*b*), and work off the outside to the shape thus marked, by means of saw, rabbet plane, rounds, and gouges. Then mark out the inside by the same process, being sure to have even thickness throughout.

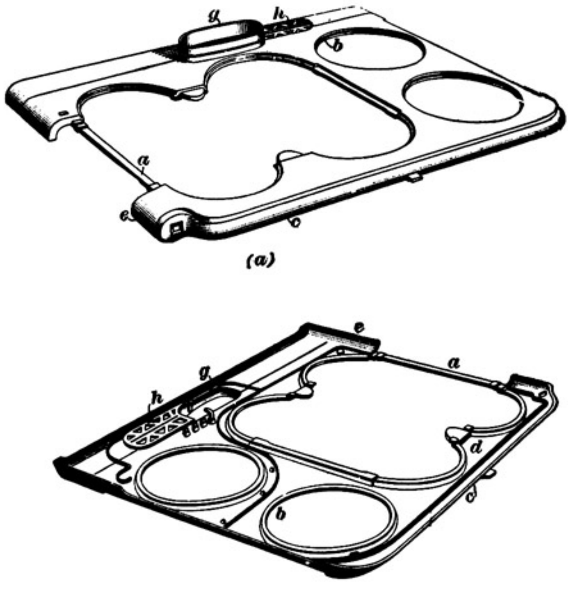
In order to prepare the match to fit these pieces, take rectangular strips and mark them on the end with the inside of the moldings, and fit the moldings to them until they will fit the templet corner when laid in the proper position. Next make the flanges shown at (*c*) and (*d*). The flange at (*c*) supports the flue strips, and the one at (*d*) goes around the oven-door opening, as shown at *e*, Fig. 22. Then make the corner moldings as shown at (*e*), also shown at *f*, Fig. 22.

To construct the pattern, take the board prepared in the first place and plane it up perfectly true. Make one edge perfectly straight, so that it can be used for a guide edge; then any number of lines can be drawn parallel, which is very essential to a true pattern. These parallel lines can be laid off at right angles to the true edge and scribed with a sharp knife.

36. Making the Match and Pattern.—The match is now built up on this board of the exact form of the under side of the pattern. Start with the corners, which are laid out carefully and followed with the moldings that have been fitted to the inside of the molding of which the pattern is to be made. When the match is finished, it is oiled all over, and the pattern proper is built up of the moldings that have been prepared and any flat pieces of the same thickness that may be necessary. They are glued together on the pattern board, and hence the pattern always fits the match. The oil on the match prevents the glue from causing the pattern and match to adhere with any great tenacity. When the pattern is put together, it is sandpapered, coated with shellac varnish, and sandpapered again. Beeswax is then put into any small holes, and two more coats of shellac are given the pattern. It is now finished, having a hard smooth surface, and is ready for the molder. In making the iron pattern, the molder uses the wooden match to support the wooden pattern while ramming up the nowel. If it is necessary to have the finished iron pattern curved to make the castings come out straight, it will be necessary to construct the wooden pattern with double the amount of curve necessary in the iron pattern, as the iron pattern will spring in cooling just as a casting would. After the iron pattern is made and finished, a wooden match board is made for it.

MAIN TOP OF RANGE.

37. Preparing to Make the Pattern.—The main top of a range or stove is made in one casting, although it



(a)

(b)

FIG. 25.

is often found to be of advantage to have the pattern in parts, so that by different combinations of parts a variety of tops are available without having a separate pattern for each. In Fig. 25 is shown the iron pattern of a range top; at (*a*) the top side is shown, and at (*b*) the under side. The first pattern for this top is sometimes made entirely of pine. The different parts are prepared before the pattern is put together in a manner similar to that explained in connection with the range jamb. The match is also prepared in a similar manner, building up on the board the corners and moldings to the exact form of the under side of the top. This is smoothed off and oiled, and the pattern is glued together on the board, giving it a good bearing at every point. It would be impossible to make the pattern first and then build a board to fit the pattern accurately without a great waste of time.

38. Description of Parts.—Range tops are often made in four sizes, according to the size of holes in the top and to the size of the oven of the range for which the top is prepared. They are made of a uniform thickness of, say, $\frac{1}{8}$ inch in all sizes. The front end of the top is where the broiler door is located. Flanges are placed on each side of the opening for the broiler door, which are connected in the pattern with a wooden bar called a *splice*, as shown at *a*, Fig. 25. The bar is also cast in the iron pattern and in the final casting. Its object is to prevent the end of the casting from spreading. After the casting is cool, the bar is broken out. The splice is merely for the purpose of holding the pattern in shape. The rabbet shown at *b* is the cover seat, which is depressed below the main body of the top. The moldings on the edges, as shown at *c*, are made separately and fastened on. The small ribs shown at *d* are for the side plates to butt against. The front moldings are shown at *e* and fastened on in a manner similar to those shown at *c*. On the back edge is located the smoke collar, shown at *g*, and the check-damper, shown at *h*. The work of putting the parts together and finishing the pattern ready for the molder is the same as that described for the jamb pattern. The central portion of the top that contains the openings for the lids is often made separate, so that different combinations of tops or side flanges can be obtained to suit different sizes of stoves without having entire patterns for each size.

RANGE BOTTOM.

39. The pattern for a range bottom is made on a match in a manner very similar to that of the other range patterns.

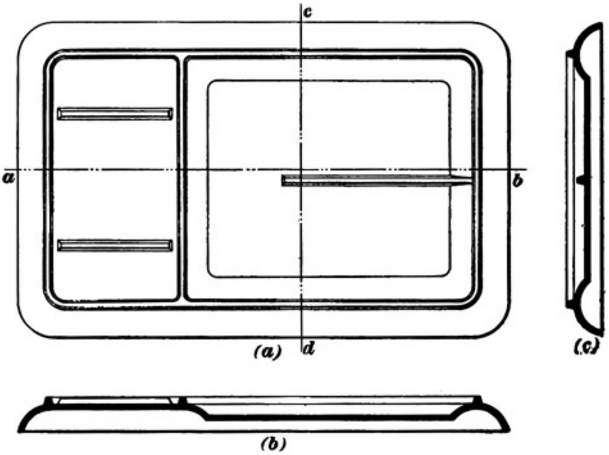


FIG. 26.

The corners are turned and cut into quarters, as for the range top, and they are the first pieces located on the match. The main part of the stock is $\frac{1}{10}$ inch thick and should be very uniform. The pattern appears as shown in Fig. 26, with the plan at (*a*), a section on *a b* at (*b*), and a section on *c d* at (*c*). When the wooden pattern is completed, it is placed on the match and the drag of the mold is made in the usual manner. The match is removed and the cope of the mold made with the pattern still in the drag. When the cope is taken off, the mold is finished in the usual way. Sometimes a gate is cut all around the mold for the metal to flow through, with smaller gates at intervals, to the mold. When this is done, it is not necessary to bend the pattern board, as these gates tend to keep the casting in shape by drawing against any internal warping action. The casting may be taken out of the sand before it is entirely cooled, to be watched, and when it is bent a little more than is required, the gates are knocked off. This need only be done in making the pattern, for if that is properly shaped, the final castings should come out perfectly flat and true. Experience is the only thing that can be counted on as a guide as to the proper curve to give the iron pattern.

TOP RANGE SHELF.

40. The top shelf of a range is usually rather ornamental, and therefore much carving is done on the wooden pattern.

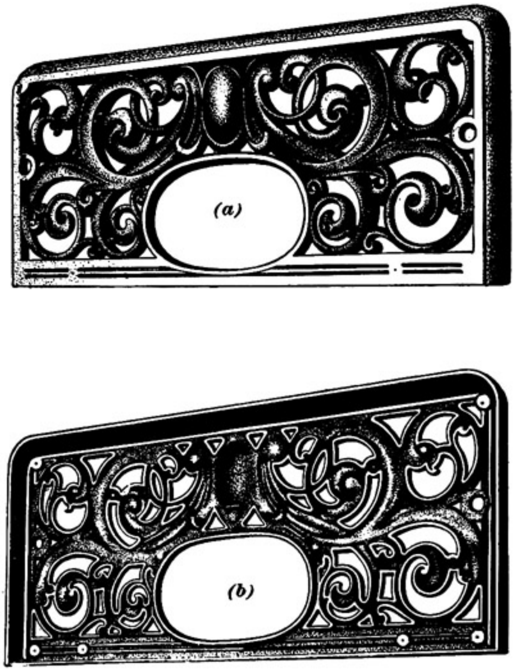
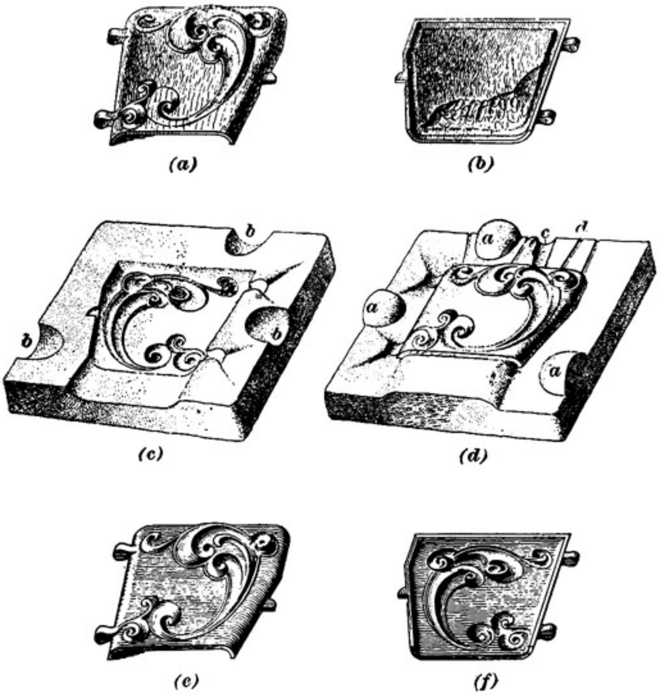


FIG. 27.

This pattern is frequently made of mahogany, and is cut out of a block formed by gluing small pieces together to prevent warping in a manner similar to that already described. The thickness of the stock should be about $\frac{1}{2}$ inch, in order to give good relief to the design and to allow proper backing. The design is transferred to the finished block and carved out accurately by the skilled workman who carves the face work, and then it is backed out by a workman who makes a specialty of this work. When the pattern is finished, the pattern board is prepared with a block to support the carved part, and small blocks the shape of the molding are placed all around the curved edge of the shelf. When the pattern board is finished, all is ready for making the iron pattern, which is shown in Fig. 27 (*a*) and (*b*). The front or face side is shown at (*a*), and the back at (*b*). When the pattern is finished, it should be of the uniform thickness of $\frac{1}{10}$ inch on all iron parts except the bottom edge of the molding. After the iron pattern is made, a wooden match is carved for it.

STOVE DOOR BY THE WAX PROCESS.

41. As has already been explained, the wax process involves the making of a wax pattern by casting it in a plaster mold. A pine pattern is first made and carefully carved on the front face, as shown in Fig. 28 (*a*), but the back is left untouched, as shown at (*b*). This pattern is fastened to a mold board, thoroughly greased, and a frame placed around it. A mold is cast in plaster of Paris, which, when the pattern is removed, appears as shown at (*c*). Then specially prepared clay that dries slowly is rolled out between two thin pieces, to give it the correct thickness; this is done with a rolling pin in a manner similar to rolling out pie crust. This is cut into strips and carefully pressed into the face of the plaster cast left by the wooden pattern, one strip at a time, until it has the right thickness all over. It is then trimmed up, any imperfections pressed out, and the hinges and other parts are carefully built up to the shape desired, after which a plaster cast of this is made. This forms the back part of the plaster mold, as shown at (*d*), and when put together with (*c*), so that the projections *a*, *a* fit the holes *b*, *b*, the mold has the proper thickness for a pattern of the desired door. Gates *c* and vents *d* are then cut in the plaster. Wax is heated and run into this mold and takes the shape of the mold quickly. The front face of such a wax pattern is shown at (*e*), and the back face at (*f*). This wax pattern is quite substantial and can be used almost like a wood pattern. From this wax pattern a master pattern is cast in white metal by using one of the plaster-cast molds as a match in ramming up the sand mold. Sometimes the wax pattern is used as the master pattern, and the iron patterns are made from it direct, but in such case the wax



(a) (b)

(c) (d)

(e) (f)

FIG. 28.

pattern must be made with 2 shrinks instead of 2½, as would be needed if making a white-metal master pattern.

Considerable practice or experience is necessary to work this method successfully, but when the peculiarities of the process are mastered, it gives very satisfactory results. The same brand of plaster of Paris should always be used if uniform results are desired.